ractical Treatise

on

Milling

and

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OWN & SHARPE MFG. CO.

PROVIDENCE, R.I.

U.S.A.

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1913

THE business now conducted by the Brown & Sharpe Mfg. Co. was founded in 1833 by David Brown and his son, Joseph R. Brown. David Brown retired in 1841, and the business was continued by Joseph R. Brown until 1853, when Lucian Sharpe became his partner, and the firm of J. R. Brown & Sharpe was formed. The Brown & Sharpe Mfg. Co. was incorporated in 1868.

The works are situated one-half mile from the business centre of Providence, and are within a few minutes' walk northwest from the railroad station.

The buildings are modern, and especially arranged to meet the requirements of the business. The seven main manufacturing buildings have a floor space of about 580,300 square feet; the foundry building about 240,000 square feet; the forging, hardening, central power plant and miscellaneous buildings about 200,300 square feet. In 1853 the floor space occupied was 1800 square feet; the present buildings have about 1,020,900 square feet of floor space, or about 23½ acres.

We are always glad to show visitors through our works.

PREFACE

It is our purpose in publishing this book to present, in as non-technical a manner as possible, information that will assist the beginner and practical man to a better understanding of the care and various uses of modern milling machines of the column and knee and manufacturing types.

CONTENTS

The Original Universal Milling Machine

The original universal milling machine was designed primarily for the purpose of forming the flutes in twist drills. Its wonderful capabilities, however, were quickly recognized, and its use soon spread to other lines, until today we find that there is an unusually large variety of machine shop jobs that can be done on a modern machine of this type. Straight and angular pieces, and surfaces of an endless variety of irregular contours, together with spur, bevel and spiral gears, twist drills, etc., can be produced. Also such work as drilling, boring, planing, rack cutting, slotting, cam cutting, graduating, etc., can be successfully accomplished. In fact, the full variety of work that can be done on a universal milling machine is still unknown, for new ways of using it are being constantly discovered.

INTRODUCTION

Milling is the process of removing metal with rotary cutters. It is employed extensively in machine shops today for forming parts of machinery, tools, etc., to required dimensions and shapes. A machine designed especially for this purpose was in existence as early as 1818, but little progress was made in the process until after the invention of the universal milling machine (shown on the opposite page) in 1861-62 by Mr. Joseph R. Brown, of J. R. Brown and Sharpe. This was owing chiefly to the difficulties of obtaining satisfactory cutters and of sharpening them. Shortly after this, however, improvements in the methods of making cutters, the invention by Mr. J. R. Brown of the form cutter which can be sharpened without changing the cutting contour and the introduction of the grinding wheel for sharpening cutters, removed the obstacles that had so seriously hindered the early development of milling.

As the field of milling widened, the demands upon the machine increased accordingly, and it became necessary to make certain improvements to adapt it to the new conditions. But it is a noteworthy fact that in all of the changes in design leading up to the modern heavy type of universal machine, shown on page 44, none of the fundamental ideas of the original machine have been lost. Parts have been strengthened to better withstand heavier service, and radical changes have been made in the method of driving the spindle and feeds to accommodate the machine to modern requirements.

From a comparison of the original machine with a modern type, the important changes that have been made are readily noted.

The column has been carried well above the spindle, and an overhanging arm with a support for the outer end of cutter arbor has been added. To further stiffen the arbor, arm braces have been devised by the use of which the overhanging arm, cutter arbor, and knee are all rigidly tied together. These braces on the smaller sizes of machines consist of long slotted cross arms, while on the larger, or heavy service machines, a different and heavier type is employed.

The table feed has been changed from the end of the feed screw and carried up through the centre of the knee and saddle, thus allowing the table to be swiveled through a much greater arc. Power feeds have been applied to the transverse and vertical table movements, and the old-style elevating screw for the knee that required cutting a hole through the floor has been replaced by a telescopic screw.

Improvements have been made on the spiral head to make it more rigid and convenient to operate; differential indexing replaces to a large extent the compound method, and refinements such as graduated index sectors, and an adjustable index crank have been added.

Such conveniences as permanent handwheels instead of cranks, adjustable dials reading to thousandths of an inch on the feed shafts, and other improvements have been put on the machines from time to time.

When the milling machine came into more general use, and its possibilities in removing metal began to be appreciated, the demand arose for the ability to make heavier cuts. These demands soon demonstrated that the method of driving the feeds through belts and cone pulleys from the spindle of the machine to the feed mechanism, was inadequate. The first improvement was to substitute chain and sprockets for the belt and pulleys and to use removable change gears to provide a variation in the rate of feed. The next step was to place all the change gears in a feed box wherein by simply shifting levers, a wide variation of feeds could be obtained.

The main spindle drive has undergone radical changes. The original machine had a four-step cone pulley mounted directly on the spindle, and many of the smaller sizes of machines today are similarly built. In order to get more power and a greater range of speeds, back gears similar to those of a lathe were added.

Following these improvements came a radical change in the whole driving mechanism of the machine. The value of feeds that were independent of the spindle speeds had become well recognized, and with the introduction of high speed steel, from which cutters could be made that would take much heavier cuts at faster speeds, and coarser feeds than had ever before been the practice, there arose a demand for more powerful machines. The constant speed type of drive was therefore originated. In this type of machine any combination of table feed and spindle speed is available, because both spindle and feeding mechanisms are driven from the main shaft of

the machine, which revolves at a constant high velocity at all times. The table feeds are therefore entirely independent of the spindle speeds. A powerful drive is also transmitted to the spindle from the driving pulley of large diameter and wide face on the main shaft of the machine through a train of heavy spur gearing in which are certain change gears that can be manipulated to give a wide range of spindle speeds.

At the same time that the constant speed type of drive was evolved, the machine was redesigned and made stronger throughout in order to better fit it for the heavy cuts that had become the practice.

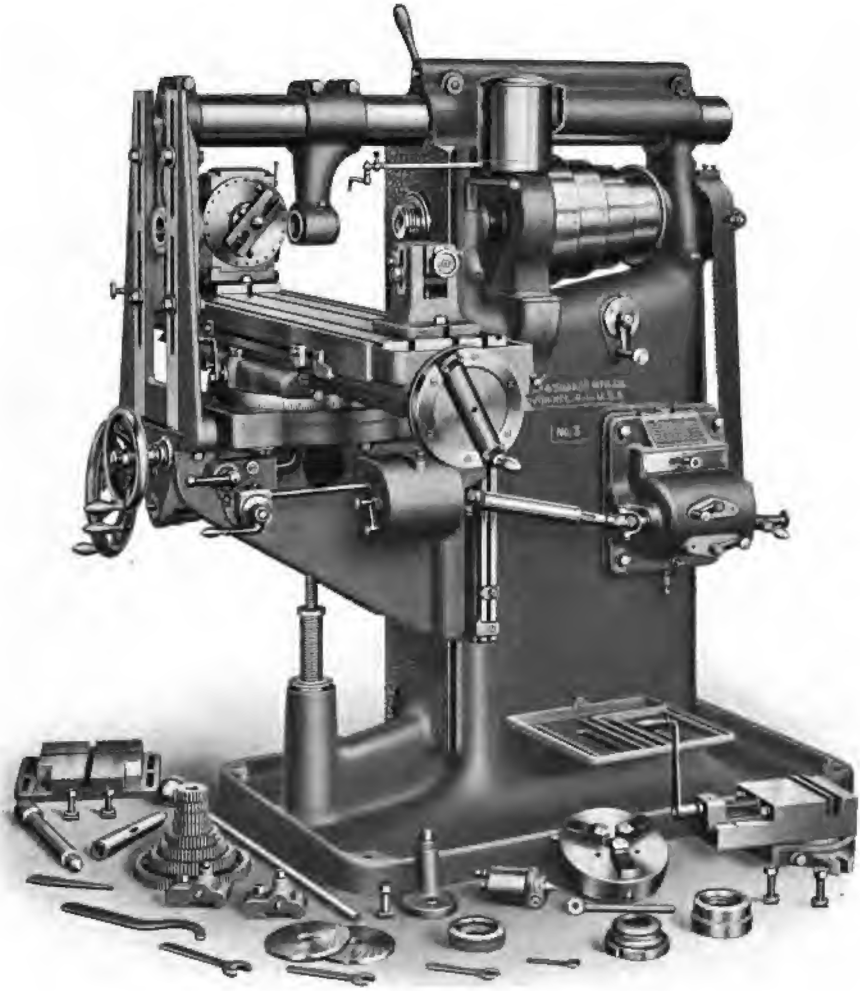
Later improvements have been the extension of the flat bearing surface on the front of the column to the top, the application of a friction clutch in the driving pulley with levers at the sides of the machine for operating it, the automatic fast feed for quick movement of the table, and other improvements of lesser importance.

It is not to be assumed that the constant speed type of drive has been developed to the exclusion of the cone type, for there are many pieces of work that can be done to good advantage on this machine. The modern cone type of machine embodies all of the previously mentioned improvements, except those relating particularly to the constant speed drive, and there is still, and probably always will be, a steady demand for this machine.

Two other types of machines known as Plain and Vertical Spindle Milling Machines have kept pace with the development of the universal machine.

Milling Machines of the Planer and Manufacturing types have also come into extensive use, the former producing a wide range of work that is of too large dimensions for the previously mentioned machines, and the latter manufacturing in large quantities small duplicate parts of machinery, tools, etc.

With the improvements that have been made on the machines and their equipment, milling has become indispensable in the modern shop. Interchangeable pieces can be easily made, and work is produced at a low cost because of the continuous operation and inexpensiveness of cutters for a given amount of production. We, therefore, recommend the milling machine to manufacturers desirous of obtaining the best results at the lowest cost on all classes of work to which the machine is adapted. And we trust that a careful reading of the following chapters will be of material assistance in understanding the process of milling and how to use the machines.



Column and Knee Milling Machine of the Universal Style

CHAPTER I

Classification of Milling Machines

The existing types of milling machines are so numerous, and their designs merge into one another to such an extent, that it is very difficult to classify them definitely. But, taken as a whole, they may be said to consist of two distinct groups, those adapted to a variety of work, and those restricted to the performance of a single operation, such as gear cutting, bolt head milling, thread milling, etc. While this latter group embraces some valuable and interesting machines, the class of work done is of a more or less special character, and little can be learned from it of the general process of milling. For this reason, and also from the fact that it would be practically impossible to treat of every type in the limited space of this book, the first group alone will be considered. The machines of this group are classified in a variety of ways by different writers. We prefer to divide them, according to general appearance and design, into three classes, comprising the column and knee type, manufacturing type, and planer type. Such a classification brings out the characteristics of the different machines, and their relation to one another.

Column and Knee Milling Machines

An illustration of a representative example of the column and knee type of milling machine is shown on the opposite page. This machine is the most recent of the three types named, having been in existence about fifty years. The rapid strides, however, that have been made within the past few years in the process of milling are largely due to its versatility and convenience. Even with the most expert cutter making, milling could never have obtained its important position in the field of machinery and tool manufacture had it not been for the column and knee type of construction.

The name, column and knee, is derived from the high, column-like design of the main casting, and the likeness of the bracket which supports the table to a knee or angle iron. The knee is adjustable on the column so that the table can be set at different heights to accommodate work of varying size. It can also be fed upward,

thus enabling vertical cuts to be taken. Provision is made for movement of the table horizontally in two directions: one, longitudinally, at right angles to the axis of the spindle; and the other, transversely, parallel to the axis of the spindle. The combination of these three movements is found only in the column and knee machine, and it is due to the advantages derived from this construction that the machine is superior to the manufacturing or planer type for general milling purposes.

Several more illustrations of column and knee machines are shown on succeeding pages of this chapter, where a further classification is given.

Manufacturing Milling Machine

This type of milling machine is shown in the illustration on the opposite page. It is a development of one of the earliest forms that was built particularly for use in the manufacture of small parts of firearms, and has since been successively adopted for machining parts of sewing machines, typewriters and other machines and tools. The advantages it offers for this class of work are due to the stiff construction and convenience with which it can be operated. These make possible an exceptionally large production of first quality work—factors of great importance in commercial manufacturing.

There are many minor variations of this type of milling machine, but the general features are similar in all. In that shown on the opposite page, the spindle is supported in bearings located in an adjustable head that can be raised and lowered. The capacity of the machine is rather limited as regards work of widely varying heights. Furthermore, there is no transverse table feed, the only movement transversely being obtained by a slight adjustment of the spindle. These, however, cannot be considered disadvantages, as provision for work of widely varying heights is not required, because all work done is of comparatively small dimensions, and there is seldom any necessity for a transverse table movement.

The longitudinal movement of the table is at right angles to the axis of the spindle. This movement is accomplished either automatically or by hand by means of a rack and pinion on the under side of the table. The pinion is driven from the spindle through a train of change gears and a worm and wheel when the automatic feed is in action.

A larger and improved style of manufacturing machine is shown upon page 88. It embodies all the features of the machine illustrated

Milling Machine of Manufacturing Type

on page 13, but in addition is designed so that the spindle is more powerfully driven and has a greater vertical adjustment. The table is also provided with a transverse movement. This machine is therefore adapted to a somewhat wider range of work than the one previously described.

Planer Milling Machine

The planer milling machine is designed for the heaviest classes of slab and gang milling. It bears a marked resemblance to the planer, from which it derives its name. The spindle is mounted in bearings carried in a vertically adjustable slide similar to that of a planer, and the table is in a corresponding position. This brief reference will enable one to easily distinguish these machines. And, as the class of work performed is identical in character, only heavier than that done on the column and knee type of machine, the same principles are involved.

Returning to the column and knee type, we can subdivide it into three classes, known as Plain, Universal, and Vertical Spindle Machines. In the first two the spindle is supported in horizontal bearings that are fixed in the main casting of the machine instead of being adjustable vertically, as in the case of both manufacturing and planer types of machines. This is one of the points where the column and knee machine is radically different from either of the other types. As we have already explained, vertical adjustment in this type is obtained by the movement of the knee upon the column.

Plain Milling Machine. The word **plain** when applied to any milling machine is used to designate one in which the longitudinal travel of the table is fixed at right angles to the spindle. Both manufacturing and planer types are therefore essentially plain milling machines.

An illustration of a plain milling machine of the column and knee type is shown on page 19. In this machine, the table has the three movements: longitudinally, transversely, and vertically, that have already been mentioned. Some machines have both automatic and hand feeds for all three of the movements; others have longitudinal and transverse movements so controlled and the vertical is operated by hand; or the longitudinal movement alone is operated both automatically and by hand, and the transverse and vertical movements are made only by hand. Feed screws are used for operating all of the table movements in many of the smaller sizes and all of the larger machines, but in some of the smaller ones a rack and

pinion are employed for the longitudinal movement. The smallest sizes of machines have no power feeds at all, and are called hand milling machines. (See illustration on page 46.) In these, the table and knee are moved by means of racks and pinions operated by levers. They are convenient for manufacturing purposes on some classes of small work, as they can be operated very rapidly.

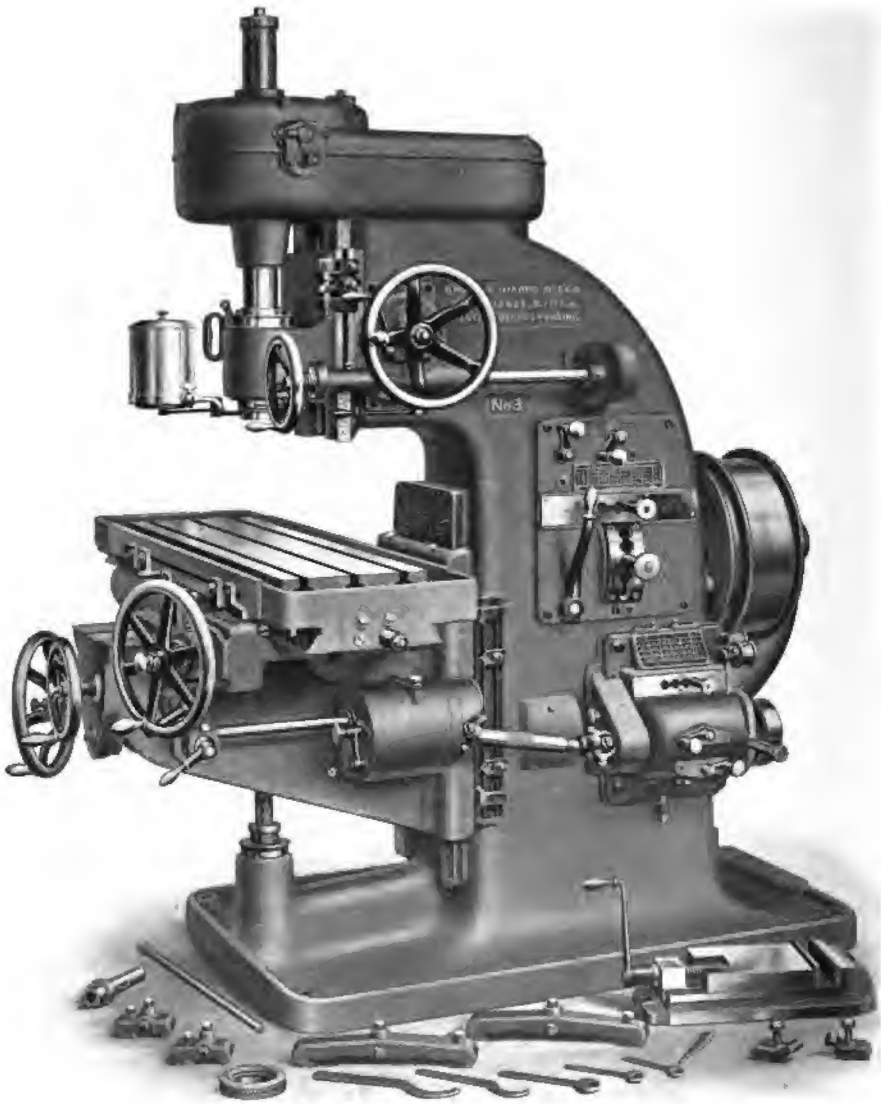
It is the practice in the classes of work to which the medium and larger sizes of plain milling machines are adapted to take heavy cuts at fast speeds and coarse feeds. The rigid construction of the machine enables this to be successfully done, and it is in this ability that the chief value of the plain machine is found.

Universal Milling Machine. The Universal milling machine is justly regarded by many to be the most important machine tool employed today; for with it much of the work of the planer and shaper—heretofore considered indispensable machines in every shop—can be done with an appreciable saving of time. Spur, bevel and spiral gears, twist drills, and all kinds of straight and taper milling can also be economically produced.

It was first patented February 21st, 1865, by Mr. J. R. Brown, of the firm of J. R. Brown & Sharpe, who designed it for the purpose of milling the grooves in twist drills, but adopted it shortly after for producing small spirals used in the manufacture of sewing machines. (An illustration of the original universal milling machine is shown on page 6.)

The cuts on pages 10 and 44 are representative of modern universal milling machines. This style of machine is essentially the same in construction as the plain milling machine, and the table has the same movements. But, in addition, the table swivels upon the saddle and can be set at an angle to the spindle in a horizontal plane. Also, it is fitted with a mechanism known as a spiral head, for use in spiral milling and indexing to obtain any required spacing on the periphery of work. The introduction of the swivel renders the table a little less stable than that of the plain machine, though in common practice heavy cuts are taken. It is apparent, however, that the offices of the two machines are in a way distinct. A universal machine is the better for general shop purposes, but where continuous heavy milling of straight cuts is to be done the plain machine is preferable.

Vertical Spindle Milling Machine. The vertical spindle milling machine embodies the principles of a drilling machine. The spindle and table are similarly located, and the cutter is mounted at the end



Vertical Spindle Milling Machine of Constant Speed Drive Type

of the spindle. The table on the milling machine, however, has a series of movements that are not found on the drilling machine. For such work as face milling, die-sinking, profiling, etc., the vertical spindle machine offers many advantages over the horizontal style. Some work can be fastened directly to the top of the table, eliminating the use of special fixtures necessary for the same kind of work on a horizontal spindle machine. Furthermore, the operator is enabled to see his work at all times during operation and more readily follow any irregularities in outline. This feature is especially valuable in profiling, cutting odd-shaped slots, etc.

Not all vertical spindle machines are of the column and knee type. There are several styles that have no provision for vertical adjustment of the table. Also some vertical spindle machines have two spindles instead of one, but these are more generally known as profiling machines.

But the combination of the vertical spindle and column and knee constructions has given the mechanical world an exceptionally valuable machine tool. With it, all of the advantages of the vertical spindle, together with those of the column and knee, are acquired. A modern example of this style is shown in the cut on the opposite page. A further convenience of this machine is found in the spindle head, which is adjustable vertically, and can be fed by power, thus enabling drilling to be conveniently done. With the adjustable spindle head and column and knee construction, it is apparent that work of a wide range of heights can be accommodated. Another style of vertical spindle machine, where the spindle is driven by a belt, is shown on page 36.

Different Methods of Driving Milling Machines

Milling machines of the column and knee and manufacturing types are either cone driven or gear driven. The latter class is more commonly referred to as the "constant speed drive."

Cone Drive. In cone driven milling machines, the belt runs directly from a stepped or cone pulley on the countershaft to one of like design fastened, either directly to, or mounted on a sleeve on the machine spindle. In one case the spindle is driven directly and only speeds that are obtained by shifting the driving belt on the pulley steps are available; while in the other an additional series of speeds is procured by the employment of back gears. The cut on page 10 is of the latter type, and the back gears referred to are enclosed at the front of the column, where they are rigidly mounted closely together to overcome torsion and cutter chatter. The feeding mechanism is

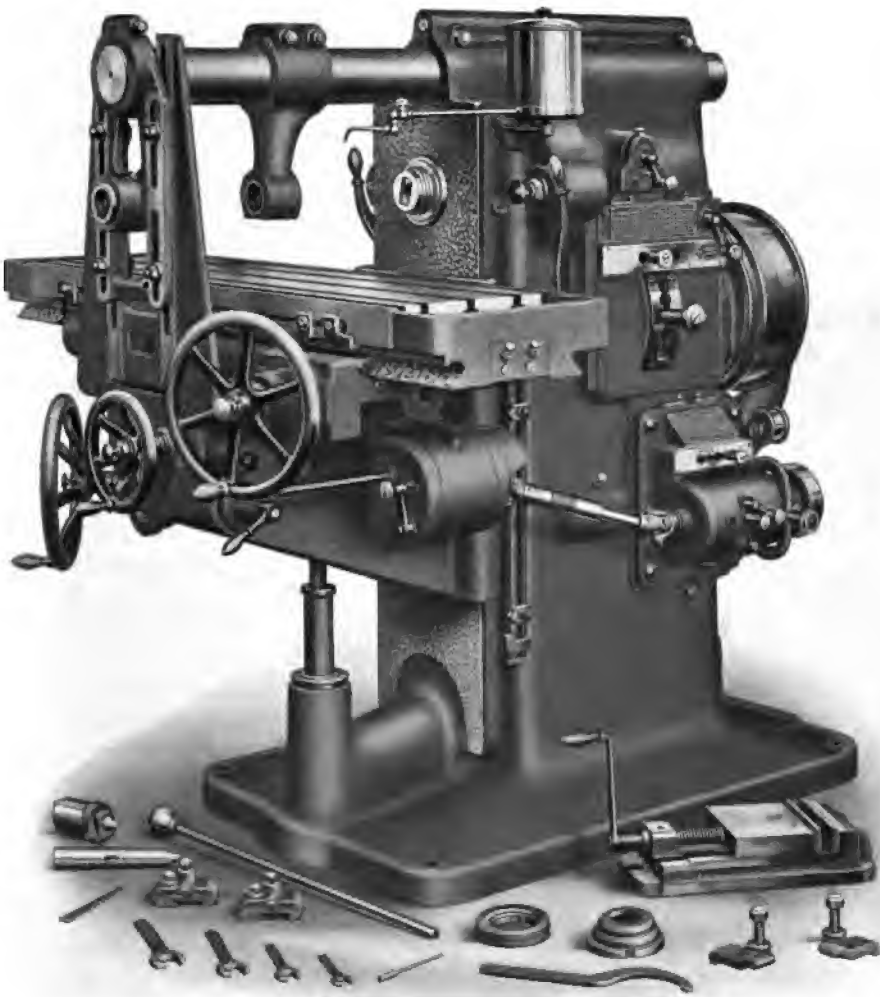
driven from the rear end of the spindle by a chain and sprockets, and is subject to the speed variations of the spindle.

When the cone method of drive is employed for vertical spindle milling machines, the belt usually leads from the cone pulley on the countershaft to one on a shaft at the back of the machine. Power is transmitted thence to the spindle on the lighter machines, by means of a quarter-turn belt. An application of this method of drive is shown in the illustration on page 36. The heavier machines are fitted with bevel gears, and a vertical shaft from which the spindle is driven by a chain and sprockets.

Constant Speed Drive. The invention of the gear type of drive, or, as it is better known, the "constant speed drive," is, without doubt, the most valuable improvement in design brought out in many years. It is the result of a demand for a machine in which the feeds would be entirely independent of the spindle speeds, and all speeds and feeds would be self-contained, thus doing away with complicated overhead works, or permitting the machine to be driven by a constant speed motor. More power and greater convenience in changing speeds and feeds were also important factors leading to the development of this type of drive.

The introduction of high speed steel marked a new era in cutter manufacturing, and brought about conditions that necessitated machines of higher efficiency. This added impetus to the already growing interest in a machine offering possibilities such as those of the constant speed drive, and, early in 1904, the Brown & Sharpe Mfg. Company placed the first constant speed drive machine upon the market. From the beginning, it was conceded an important improvement, especially for the larger sizes of heavy service machines, where an abundance of power is required, and this has led to its becoming almost universally adopted by milling machine manufacturers. Several examples of constant speed drive machines are shown in this treatise, notably those illustrated on pages 16, 19 and 44.

The general features of this drive are as follows: the belt delivers power to the driving pulley that runs loose on a sleeve on the main shaft of the machine. By means of a friction clutch on the main shaft, operated by levers at each side of the column, power is transmitted from the driving pulley to a train of hardened gears leading to the spindle, and in which there are certain change gears operated by levers at the right-hand side of the column. The belt and main driving pulley run at a constant high velocity regardless of



Heavy Service Plain Milling Machine of Constant Speed Drive Type

the spindle speed, which is entirely dependent upon the ratio of gearing that may be in mesh. The power at the spindle is therefore constant, regardless of its speed.

The mechanism of constant speed drive vertical spindle machines is essentially like that outlined above, except that a pair of bevel gears and vertical shaft are introduced to transmit power to the spindle head; from whence it is communicated to the spindle itself by spur gearing.

The feed changing mechanism is driven from the main shaft by means of a chain and sprockets in all constant speed drive machines. Hence it is completely separated from the spindle drive, in so far as its speeds are concerned, permitting the full range of feeds to be available for every spindle speed. Such an arrangement also permits the table feeds to be rated directly in inches per minute, which is an advantage in that it enables the production of a machine to be ascertained at a glance.

CHAPTER II

Essentials of a Modern Milling Machine

It has been previously stated that the foremost advantages attending the employment of the milling machine are, the production of a great variety of work, and the exact duplication of pieces at an economical cost. In order that these advantages may fully materialize, it is necessary that many requirements be fulfilled in the design and construction of the machine.

These requirements vary to a certain extent with the style and size of machine; taken as a whole, however, they are materially the same. The machines must all be accurate, economical to operate, and durable. Hence, these may be said to constitute the general requirements of a milling machine. Those qualities upon which accuracy is chiefly dependent are: thorough workmanship, especially in aligning the working parts, and sufficient rigidity. In order to be economical in operation, a milling machine must have ample ranges of spindle speeds and table feeds, and plenty of power, so as to adapt it to the many varieties of work. Further, its efficiency must be high, and its parts must be conveniently arranged to allow quick manipulation and ready adjustment. The third general requirement, durability, is, to a great extent, dependent upon the design and quality of materials that enter into the construction of a machine. It is also influenced by several of the already-mentioned points that are essential to accuracy and economy. To particularize then, the requirements of a milling machine are thorough workmanship, correct alignment of all working parts, sufficient rigidity, wide ranges of speeds and feeds, ample power, high efficiency, durability, and convenience in design and operation.

Workmanship. It is stated above that the dependence of accuracy upon workmanship in the building of a milling machine is of greatest importance in connection with the alignments of the different working parts. Correct alignments are most essential because they establish exact positions of the various parts with relation to one another. Any error in alignments is transmitted from one part to another until it is finally communicated to the piece of work, where it is liable to be

multiplied. If the work is of the coarser grade, or mere roughing cuts are being taken, a few thousandths of an inch over or under size do not matter; but when finishing a piece that must come within close limits of a pre-determined size, a very small error is often sufficient to seriously impair its quality.

All of the important alignments in milling machines are obtained by scraping, a process consisting of going over the different bearing surfaces by hand with a chisel-like tool, and removing the highest spots until a maximum number of bearing points is secured. Flat bearings are scraped to conform to master surface plates and straight edges, and the boxes of important cylindrical bearings are scraped to fit the revolving piece, which is ground. This work necessarily calls for much skill upon the part of the workman, and the care with which scraping is performed largely influences the accuracy of the resultant bearings.

Principal Alignments of Milling Machines. Broadly speaking, the principal alignments of all milling machines are those of the spindle and table. They are, of course, affected by various minor alignments throughout the machine, but it is not essential to take up each of these in detail. The alignments of the table on horizontal spindle column and knee machines should be such that its upward and downward movements will be perpendicular to the spindle axis. Its longitudinal and transverse movements should be in horizontal planes, the longitudinal being parallel to the face of the column on plain machines, and on universal machines when the table is set at zero; and the transverse at right angles to the column.

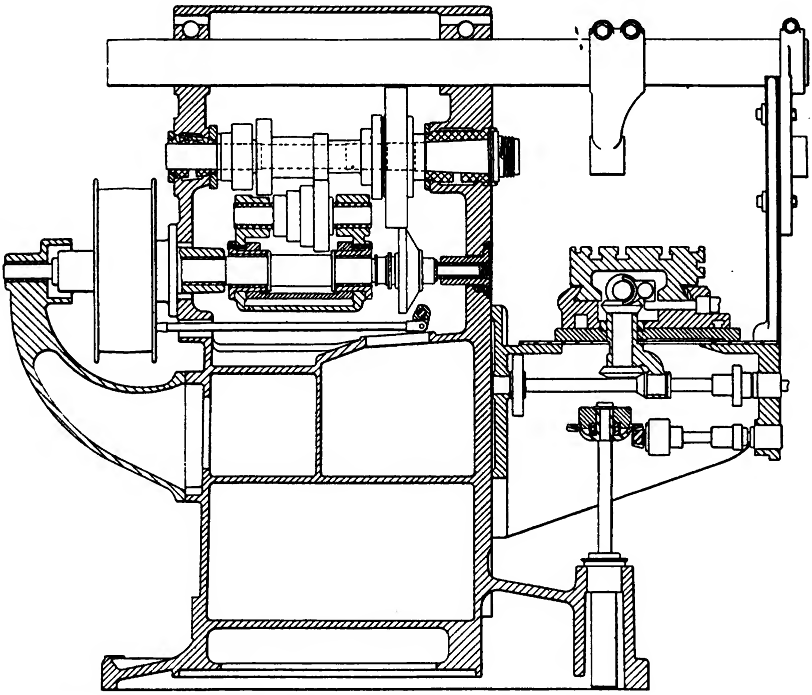
On universal machines, the table should also swivel in a horizontal plane.

These alignments of the table and spindle of column and knee machines are typical, and it is easy to understand from them what the alignments of other types of milling machines should be.

While we have emphasized the importance of good workmanship in scraping bearing surfaces, in order to obtain accurate alignments, it must be understood that certain elements in design are largely responsible as to whether the alignments remain accurate or not. A bearing surface may be scraped ever so carefully, yet the lack of sufficient weight in the casting, or of ample proportions of the bearing surface itself, will quickly result in the alignments becoming inaccurate. Thus it is apparent that if alignments are to be permanent, the proportion of the different parts, including the bearing surfaces themselves,

must be ample to easily support the weight brought upon them. The accuracy of alignments can be ascertained upon first operation of a machine, but their permanency can be determined only after a considerable period of service.

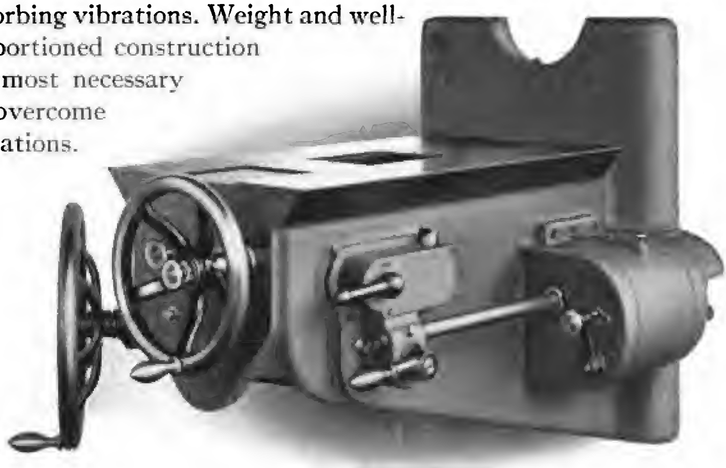
Rigidity. This requirement is of just as great importance to the success of a milling machine as correct alignments. Any machine tool must be rigid in order to produce accurate, well-finished work;



Brown & Sharpe Milling Machine, showing large base, thick walls and internal bracing. The spindle bearings are mounted directly in thick walls of column.

the milling machine must be particularly so. It is not until within the past few years, however, that the real value of this essential has been fully appreciated. This is owing to the fact that up to that time the milling machine had not become so extensively used for manufacturing purposes. In this field it must be capable of not only producing accurate work of high quality, but of producing it rapidly. The more rapidly a machine is operated, the greater is its tendency to vibrate. This is further augmented by the use of cutters

made from high speed steel, for they can be made to take unusually heavy cuts at fast speeds and coarse feeds. It is impossible to eliminate all vibrations from even the very best types of machine construction, but they may be reduced to a minimum, or, in other words, to a point where they will not affect the accuracy of the work, if every part is so constructed that it is capable of resisting heavy stresses, and absorbing vibrations. Weight and well-proportioned construction are most necessary to overcome vibrations.



Knee of Brown & Sharpe Milling Machine illustrating the points mentioned above

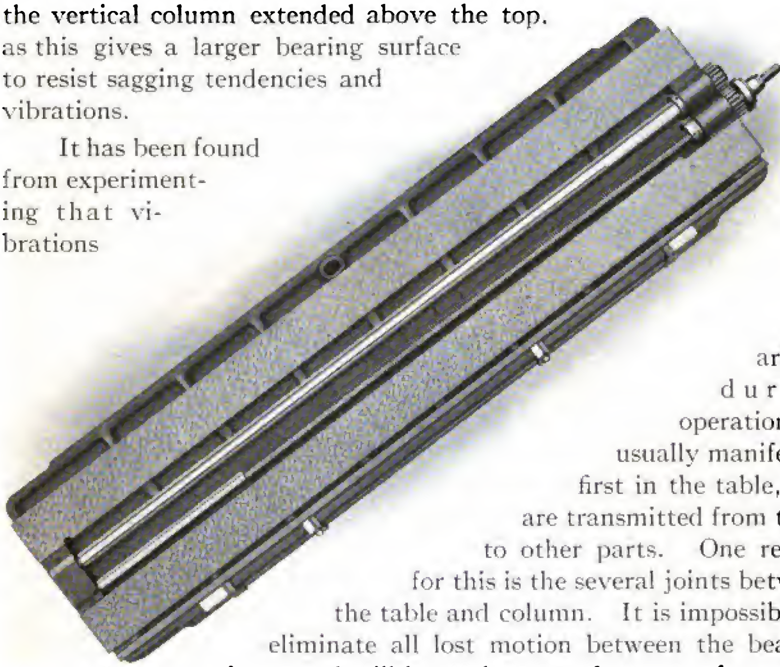
The essentials in the design and construction of the column and knee machine that serve well to illustrate the general points that conduce to rigidity in all machines, follow:

First, the base must be large and heavy enough to provide a firm foundation, and the walls of the column must be thick and strongly braced, in order to support rigidly the weight of the working parts and withstand the strains of operation. Especially is this true of the front wall, which forms the basis of support for the table. If this is not heavy enough and well braced, it will have a tendency to buckle under the heavy loads it is required to support, which will not only admit of vibrations, but also destroy the alignments of the machine. Another point in connection with this front wall, or vertical slide, is that it should be wide in proportion to the size of the machine, as the wider a flat bearing, the more stable it is.

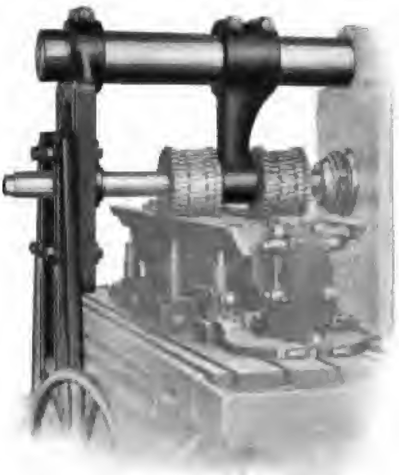
All shafts should be of large enough diameter to resist bending and torsional stresses, and gears should be of ample size to give

strength and good wearing qualities, and to transmit the requisite power to the spindle. Cylindrical bearings should be firmly supported, and the boxes should be as long as is consistent with a high degree of efficiency. Those of the spindle are most stable when mounted directly in the thick walls of the frame.

A heavy, well-braced construction is necessary in the knee in order to overcome all tendency to vibrate or sag under the load of the saddle and table during operation. It is also well, on the large machines, to have the back of the knee that fits the vertical column extended above the top, as this gives a larger bearing surface to resist sagging tendencies and vibrations.



It has been found from experimenting that vibrations arising during operation are usually manifested first in the table, and are transmitted from there to other parts. One reason for this is the several joints between the table and column. It is impossible to eliminate all lost motion between the bearing surfaces, and still have the parts free to perform their different functions. But weight has much to do with the stability of the table, and in many cases vibrations have been practically overcome by simply adding more weight to this part. It is important, therefore, that both the table and saddle be of sufficiently heavy construction. Transverse braces, however, placed at frequent intervals on the under side of the table often produce the required rigidity without adding unduly to the weight. Efficient clamps on the flat bearings of the knee, saddle and table also provide means of rigidly fastening any one or two of the table movements that may not be in use, and thus eliminating vibrations.



Showing large overhanging arm, arbor support, and arm braces on large Brown & Sharpe Milling Machine

Another point that influences largely the rigidity of the table is the size of the flat bearing surfaces in the saddle and on the knee. It is essential that the table bearing in the saddle be wide and sufficiently long to prevent too great an overhang when the table is at the ends of its traverse, and the top of the knee be of ample width to easily support the weight placed upon the table.

Other features which conduce to rigidity are: a large overhanging arm with a support for the outer end of the cutter arbor, and an intermediate bearing on the larger machines, also arm braces that firmly tie the overhanging arm and knee together.

Speeds and Feeds. It is rare that the conditions surrounding any two jobs on a milling machine are the same. Sometimes the work is of the heaviest class to which the machine is adapted, requiring gangs of cutters operating at a comparatively fast speed and coarse feed; again it is of a lighter type, requiring only one cutter operating at a fast speed and fine feed. The shape of the piece sometimes demands that the cutter be fed through faster or slower than would ordinarily be done in milling a plain surface. Different materials cannot be milled at the same speeds and feeds. Cutters of large diameter are employed for some jobs, and to get the proper periphery speed, they must be rotated at a slower rate than those of smaller diameter. A finishing cut with the same cutter is usually taken at a faster speed, and correspondingly lower rate of feed per revolution of spindle than the roughing cut, in order to obtain a smoother finish. All these, and many other conditions, make it necessary that a machine have a wide range of spindle speeds and table feeds. Furthermore, there must be many intermediate speeds and feeds between the highest and lowest in the ranges. In many cases it is also advantageous to have the speeds and feeds independent of one another, so that the spindle speed may be changed without disturbing the rate of table travel. This is possible in the constant speed driven machine,

Feed Changing Mechanism on Brown & Sharpe Milling Machine

and constitutes a particular point wherein this type of drive differs from that known as the cone drive.

The cone drive machine is admirably adapted to all classes of work where it is not necessary to use combinations of extreme speeds and feeds. In these cases, however, it cannot fulfill the requirements. For instance, it is impossible to obtain a coarse enough feed for a cutter of very large diameter, because the feeding mechanism is invariably driven from the end of the spindle, and is subject to the speed variations of this part. Consequently, when a large cutter is being used, the spindle is usually driven at its slowest speed, and the fastest feed that is then available is not coarse enough. Likewise, a correct combination of speed and feed cannot be had for a small mill, as this should run at the fastest spindle speed, and, when it does, the finest feed obtainable is much too coarse. The majority of work, however, does not require such combinations, and when medium-sized mills are used and work of ordinary classes is done, the cone drive machine is very satisfactory.

Owing to the dependence of the feeds upon the spindle speeds in the cone drive machines, it is necessary to rate them as so much per revolution of the spindle. This requires that the feed being used be multiplied by the spindle speed, in order to obtain the rate of production in inches per minute—the most generally accepted standard.

With the constant speed type of drive any combination of spindle speed and table feed within the ranges of the machine can be obtained, and thus the large, medium, or small sizes of cutters can all be run at the most practical speeds and feeds. This is due to the fact that the spindle and feeding mechanism are driven independently of each other from the same main shaft, which revolves at a constant velocity at all times. Feeds obtained in this manner can be rated directly in inches per minute, a point that in itself constitutes an important advantage.

On practically all of the Brown & Sharpe constant speed drive machines, sixteen changes of spindle speed, and at least sixteen different feeds are available, while some sizes have as many as twenty feeds. Their range varies slightly in the different sizes of machines, but is such in every case that the correct combination can be had for any cutter that is used.

Power. A milling machine must have ample power, or its use is exceedingly limited. This applies to all styles and sizes of machines,

but more particularly to the larger ones that are used in commercial manufacturing, where an economical production means the taking of heavy cuts at fast speeds and coarse feeds.

In driving machine tools, the power delivered to a machine depends upon the diameters of the driving pulleys, and size and velocity of the belt. A wide belt running at a high velocity on pulleys of large and equal diameters develops the maximum power, and, as its speed and width are lessened, its pulling ability decreases correspondingly. Likewise, it transmits less power, as the pulley on the machine exceeds in diameter the pulley on the driving shaft, for, when the surface contact on the driver becomes smaller, the belt has a tendency to slip.

Hence, in the factor of power is found another important difference between the cone and constant speed drive machines, with the advantage in favor of the latter.

The cone drive machine is very suitable for light and medium work, such as the majority of milling consists of, but when it comes to driving a large cutter through a heavy cut at a slow spindle speed and coarse feed, the requisite amount of power is lacking. This is due to the belt being upon the smallest step of the driving pulley, where it runs at its slowest velocity, and has a small arc and surface of contact.

On constant speed drive machines, the pulley is of the same, or almost equal diameter to that on the overhead shaft, and runs at a constant high velocity, irrespective of the spindle speed. Furthermore, a wider belt can be employed than on cone drive machines. As a result, a maximum amount of power is delivered to the machine pulley, and is transmitted through heavy gearing to the spindle, under all conditions, thus fitting this style of machine particularly well to the heavier classes of work. Another advantage of this drive is its particular adaptation to the application of a motor. The constant speed type of motor, which is more economical, both in first cost and in the amount of power consumed, than the variable speed motor, can be employed. This is also the most simple and compact form of motor drive. When applied to Brown & Sharpe Machines, the motor is mounted on a bracket at the back of the column, where it is away from dust and chips of the table (see page 173). Furthermore, by placing it in this position the floor space occupied by the machine is not increased, as it is necessary to leave room behind the machine to allow the overhanging arm to be pushed back when not in use.

Efficiency. Production costs are of vital importance to the shop owner, and no one factor influences them to a much greater extent than the efficiency of the different machines employed. Where this is low, the amount of power consumed for which there is no apparent return is higher than it should be, with the result that the cost of production is increased. It is essential, therefore, that a high degree of efficiency be attained in the milling machine, so that a maximum amount of work may be produced for the power consumed.

In order to obtain the highest degree of efficiency in milling machine construction, it is necessary that the utmost care be taken in designing the different parts, selecting materials, and in the quality of workmanship in building.

All parts must be proportioned in accordance with the functions they perform. They should be heavy enough to resist any stress that would tend to cramp operating movements. For instance, cylindrical shafts should be large enough in diameter to eliminate bending tendency, for this will cramp them in the bearings, thus interfering with their free revolution. Care must be taken, however, that the different parts are not proportioned so heavy that they will be cumbersome and thus produce excessive friction, which is detrimental to efficiency. It is here that the selection of materials is of value, for often the weight of a part can be made lighter by the use of a material of higher tensile strength.

Pointed Teeth of Hardened Change Gear

The size of bearing surfaces is of especial importance to efficiency, as well as to permanent alignment and rigidity. It is between them that friction arises in operation, and in order to reduce this to a minimum, their proportions should be such that the parts may move freely under the heaviest load.

Correct alignments of bearing surfaces are as essential to efficiency as to accuracy, in order that the working parts may move freely. Any error in alignments tends to cramp or wedge the moving parts.

Simplicity of parts and the use of spur gearing as far as possible are also elements that contribute largely to high efficiency.

Durability. The first cost of a milling machine, like any other modern machine tool, is comparatively great, and to make its employment economical, this cost must be spread over a long period of service—in other words, the machine must be durable. Strong design and the use of high quality materials throughout the machine are most essential to durability.

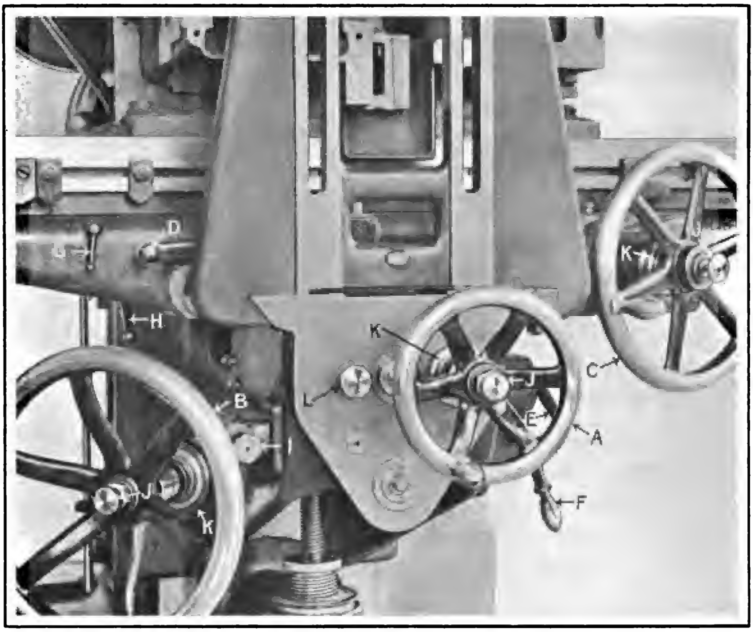
Good workmanship is also an important factor. Seemingly small details in construction should receive careful attention, for it is these that many times give rise to serious trouble. The fitting of different parts, and making of all alignments should be carefully done, and means should be provided for taking up wear at any points where it is apt to occur. In connection with the wearing qualities of different parts, the selection of materials is an important factor; parts that are subject to continuous usage, such as the change gears in constant speed drive machines, should be made of a hard material having good wearing qualities. In Brown & Sharpe machines, these gears are made of steel and are hardened.

Where change gears are being thrown into and out of mesh frequently by a tumbler arrangement, it is well to have the tops of the teeth pointed, and the ends of teeth in sliding gears chamfered. These features not only facilitate throwing the gears into mesh, but also reduce the danger of teeth becoming bruised or broken, which is apt to happen when gears with teeth of the ordinary shape are thrown into mesh.

Rigidity is as essential to durability as to accuracy, since the existence of vibrations causes very rapid wearing of parts. Hence, every part should be of stable enough construction to resist vibrations under all practical working conditions.

Beyond these points, and that of provision for lubricating all bearing surfaces, the matter of durability is more especially a question of the care devoted to the machine while in use. Its failure to be durable because of lack of proper care cannot be attributed to any faults in design or construction. The information given in the next chapter on the care of milling machines is very important to those who have charge of these machines.

Convenience. Much time is lost in operating a milling machine that is inconvenient in any way for the workman to handle: therefore, from the standpoints of economy and efficiency, convenience is a most desirable quality. To be convenient, a machine must be so designed



Arrangement of Levers, Hand-wheels, etc., at front of Brown & Sharpe Milling Machine

A, Transverse hand feed; B, Vertical hand feed; C, Longitudinal hand quick return; D, Longitudinal automatic feed trip and reverse lever; E, Transverse automatic feed trip lever; F, Vertical automatic feed trip lever; G, Longitudinal movement clamp; H, Transverse movement clamp; I, Vertical movement clamp; J, J, J, Knobs to disengage hand-wheels so that they are stationary when power feed is in action; K, K, K, Adjustable dials graduated to thousandths of an inch; L, Knob for stopping transverse and vertical feeding mechanism when only longitudinal table traverse is in use.

and constructed that work and tools can be readily placed in position and removed from the table, spindle and table feed adjustments easily made, and all working parts readily accessible.

As the station of the operator is at the front of the machine, all controlling levers and hand-wheels for stopping and starting the machine and the different table movements should be within reach from this point.

The spindle speed and table feed changing levers of constant speed driven machines are placed on the left-hand side of the column by some builders, and on the right by others. This is more a matter of choice than anything else, the chief advantage being in having them conveniently grouped and so designed that the manner of operation is clear.

Arrangements for lubricating the various parts and making adjustments to compensate for wear should be such that these can be accomplished with a minimum loss of time.

Hand or Automatic Feed. It is essential that the table of all milling machines used for manufacturing purposes, with the exception of the very smallest of the plain type, be fitted with both hand and automatic feeds. In the case of this exception, the work done is of such a small character that the machine can be operated more rapidly by hand than it could be if an automatic feed were applied. By the use of automatic feeds, one operator is enabled to run several machines on the majority of commercial work.

Tool room machines, and those used for miscellaneous milling, should be fitted with both hand and automatic feeds, for, while much of the work requires careful feeding by hand, there are, nevertheless, many times when an automatic feed can be employed and the mechanic can devote his attention to some other detail of the job while a cut is being taken.

Oil Can or Pump and Tank. Every milling machine must be fitted with some arrangement for lubricating the cutters when working on steel, or wrought iron. Either an oil can or a pump and tank are employed for this purpose. For machines that are used for light work and miscellaneous milling, an oil can is found satisfactory, as the amount of lubricant used is small and a pump and tank complicate the machine and make more for the operator to care for. When heavy and manufacturing milling is being done, however, and an abundance of oil is required, both to cool the cutters and

Illustrations Showing Handy Control of Brown & Sharpe Milling Machines

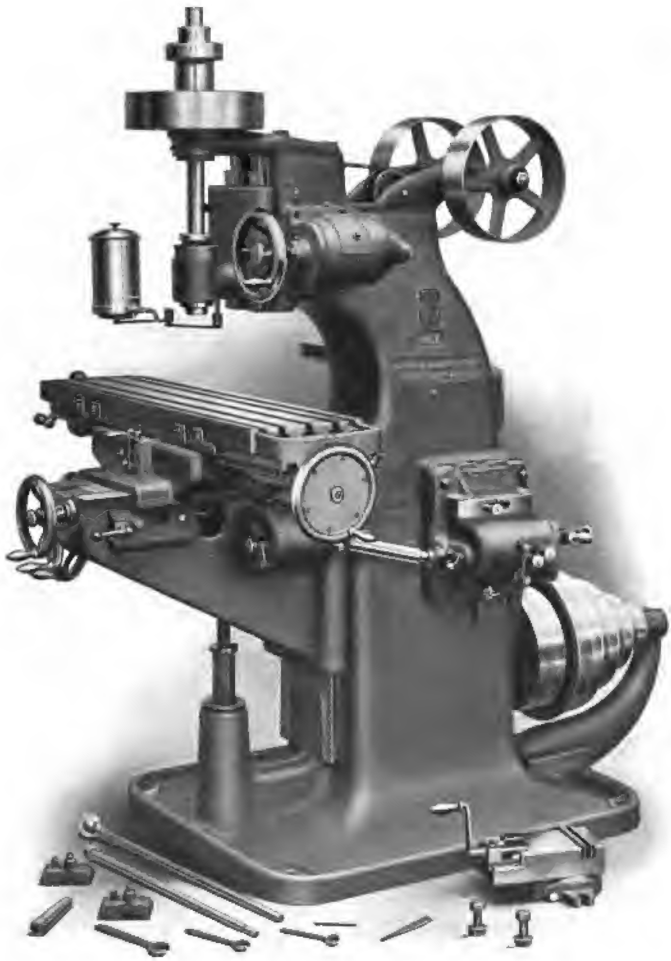
There are Friction Clutch Levers at Both Sides of Machine for Convenience of Operator

No Exertion to Run the Table Back or Run it Up to Cut with Automatic Fast Feed

Operator Does Not Have to Go Around Table to Clamp Knee

Operator Clamps Overhanging Arm at Both Bearings by this Single Lever

wash out chips, it is not always practical to supply it through the medium of a can, as this cannot be made large enough to hold sufficient lubricant to last long. By fitting the machine with a pump and a tank to which the used oil returns by gravity, a copious supply is available at all times. When it is not needed it can be shut off at the spout and a relief valve in the piping returns the unused oil to the tank.



Vertical Spindle Milling Machine with Spindle Driven by Belt

CHAPTER III

Erection and Care of Machine

Erection. A machine should be placed upon a level, and, if possible, a solid floor or foundation. If the foundation is not firm, undue vibrations will exist and possibly impair its accuracy and durability. Either stone or concrete makes an excellent foundation for the larger sizes. Neither of these can be used, however, when it is desired to place a machine above the ground floor of a building, and it is best, in this case, to locate it directly over a beam; not in the middle of a bay.

Ordinary wooden shingles are commonly used in leveling a machine. When the exact position has been determined, the fastening screws or bolts should be screwed down until nearly tight. A spirit level should then be used to test the top of the table, both longitudinally and transversely. If the machine is too low at any corner, drive a shingle under the base at this point to bring it up. When the table is found to be level in every direction, the nuts, or bolts, should be brought up solidly. It is well, even after tightening the bolts, to test the surface of the table once more, as this tightening sometimes throws the machine out of level again.

Counter-shaft. Putting up the counter-shaft, when one is employed, is usually the first operation in installing a machine. It is generally placed directly over cone drive machines because of the interference of the driving belt with the upper part of the frame if it is located very far at either side. With constant speed drive machines, it is not necessary to place the counter-shaft directly overhead. It may be placed diagonally so long as the belt does not interfere with the overhanging arm when it is pushed back.

The counter-shaft should be level and accurately aligned parallel with the main, or driving, shaft. Where the beams are not uniform enough to bring the stringers to which the counter-shaft hangers are attached level, it will be necessary to shim between the feet of the hangers and the stringers to make the shaft level. The holes in the feet of the hangers are usually in the form of slots, which allow the hangers to be slightly adjusted when aligning the counter-shaft with

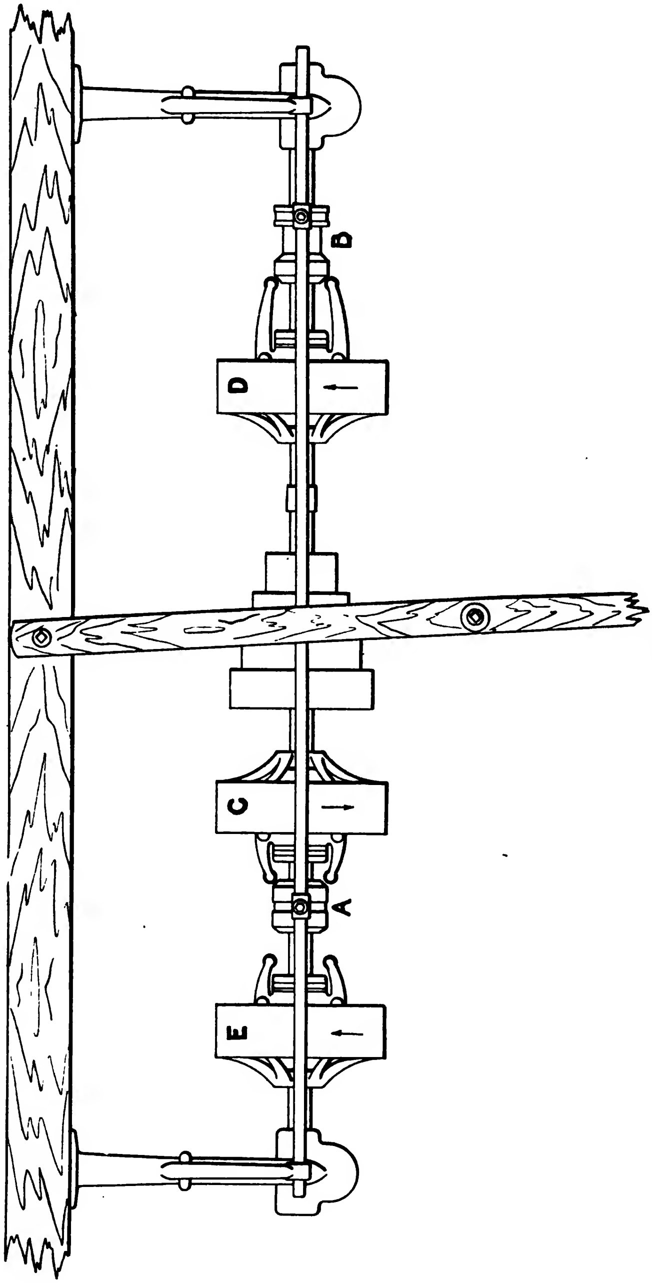


Fig. 1

the driving shaft. In leveling and aligning the counter-shaft, it is the practice to insert the bare shaft in its boxes and take measurements from it. It is afterward removed, the pulleys put on and then replaced in its bearings. When the hangers are securely tightened, the shaft should revolve freely. About an eighth of an inch end play is desirable on a counter-shaft. This can be obtained when placing the hangers.

The shipper handles are most convenient when they come within easy reach from the left front side of the machine, as this is the position commonly taken by the workman to watch the operation.

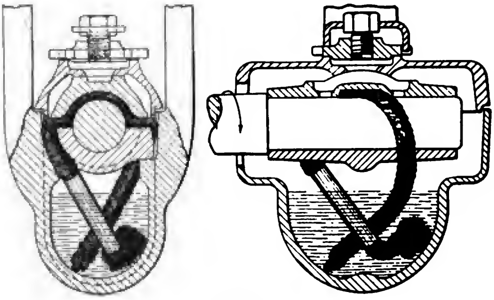


Fig. 2

Counter-shaft bearings are lubricated in various ways. In our particular type the oil is raised from reservoirs in each hanger by means of rope wicks as shown in Fig. 2.

As a rule it is not necessary to draw off and replace the oil in counter-shaft reservoirs at very frequent intervals if a good machinery oil is used. If the reservoirs are thoroughly cleaned and filled with fresh oil once every year or so they rarely need much attention. It is good practice, however, to put in a little oil every three or four months in order to insure maintaining the proper level.

The arrangement of a three-friction pulley counter-shaft is shown in Fig. 1. Its operation is as follows: A movement of the shipper to the right from the position in which it is shown, causes thimble A to spread the friction levers or engage pulley C. Throwing the shipper to the left until thimble A is about central between pulleys C and E, causes thimble B to spread the friction levers or engage pulley D. A further movement of the shipper to the left allows the levers of pulley D to slip over onto the smaller diameter of thimble B, disengaging the clutch of this pulley; at the same time thimble A spreads the levers engaging pulley E.

Diameter of Pulley on Driving Shaft. To find the diameter of pulley required on the driving shaft for driving the counter-shaft at a given speed, multiply the required speed of the counter-shaft in revolutions per minute by the diameter in inches of the pulley on same, and divide the product by the revolutions per minute

of driving shaft. If, for instance, the speed of the main shaft in a shop is 200 R. P. M., and it is required to drive a counter-shaft, having a pulley 14 inches in diameter, 320 R. P. M., the diameter of the main shaft pulley is found as follows:

$$\frac{320 \text{ R. P. M.} \times 14''}{200 \text{ R. P. M.}} = 22.4'', \text{ diameter of pulley required on main shaft.}$$

When the counter-shaft has two or more pulleys whose speeds differ, a separate calculation is required for each. And when no counter-shaft is used, the calculation is the same as above, except that the required speed and diameter of the machine pulley are substituted for the diameter and speed of the counter-shaft pulley.

Importance of Keeping Machine Clean and Well Oiled. Many workmen fail to appreciate the importance of keeping a machine clean and well oiled, and we cannot emphasize this point too strongly. Proper attention to these details influences the accuracy and efficiency of a milling machine and prolongs its life, while neglect to attend to these matters has ruined many a good machine.

Working parts most exposed to dust, dirt or chips, should be frequently cleaned and oiled. Chips should not be allowed to collect upon the surface of the table until they fall over the sides on to the flat bearings on the top of the knee. Care should also be taken to prevent chips and dirt getting between the knee and column, causing scoring of these flat bearings and throwing the knee out of alignment.

Oil tubes and channels many times become clogged with a gummy substance, due to the accumulation of dirt in the oil, and also to decomposition of the lubricant itself. This can be effectively removed without injury to the bearing surfaces by flushing the tubes and channels with gasoline or naphtha. It is well to do this occasionally to insure free passage of oil to the bearings, for if the bearing surfaces, especially cylindrical ones, run dry, they become roughed up, which necessitates taking them apart, and entails considerable work before they can be made to run satisfactorily again.

A machine that has been in active service for a period of a year or two, should be thoroughly cleaned and inspected. To do this, requires that it be taken apart to some extent, as it is impossible to ascertain the condition of some of the more important bearing surfaces in any other way. Also it is the only way in which one can make sure that some of the oil channels that are not easily accessible are not filled up.

Only good mechanics who thoroughly understand the construction of the different parts should be permitted to take apart and reassemble a machine, owing to the liability of parts being put together wrongly and alignments imperfectly made, if the work is intrusted to less responsible persons.

Arbors and collars should be kept clean and care exercised that chips do not get into the hole in the spindle or between collars.

Neatness about a machine is usually the mark of a good workman. By assigning definite places to tools and attachments and returning them immediately after using, he is able to know just where to look for any one whenever he wants it. The time required to replace tools in this way is more than offset by the advantage of being able to readily find them again; besides, the tidiness of a machine materially adds to the appearance of a shop.

It is well to remember when applying oil that ordinary bearings can hold only a few drops at a time and that this amount applied at regular and frequent intervals is far more beneficial than a flood of lubricant at irregular periods. It is a good practice to have one man attend to the oiling daily in shops where the machines are used by different workmen.

Kind of Oil. There are so many good machinery oils upon the market that it is hard to specify any one as the best to use for lubricating a milling machine. Any good coal or mineral oil can be used. Never use an animal oil, as it will gum up the bearing surfaces, oil channels and tubes, and have a tendency to retard rather than render easy the movements of the different parts. It might also be said that in buying machinery oil it is always safest to purchase a lubricant of reliable quality instead of experimenting with the less expensive brands. It is cheaper to buy good oil than to run the risk of damage to bearings from overheating or scoring.

Care of Driving Chain on Motor Driven Machines. The care of the driving chain on motor driven machines is important. It should be kept clean, well lubricated and adjusted. To clean a driving chain, remove it and immerse in a bath of kerosene or gasoline. This will loosen up the gum and dirt, and by working the joints while in the bath, foreign matter will come out. Remove the kerosene or gasoline by soaking the chain in a very hot and fairly strong solution of soda and water. Wipe dry and immerse in a bath of warm and quite thick lubricating oil for several hours. This treatment should be applied about every two or three months.

A good quality of lubricant that is free from tendency to gum should be used, and a generous quantity applied daily.

The tension of the chain is usually regulated by the adjusting screws in motor bracket. It should run at a tension that might be termed just a little too slack for a leather belt; that is, a slightly greater sag should be allowed.

Adjustments. As bearing surfaces and parts wear, it becomes necessary from time to time to make adjustments, and at all important points convenient means are provided for doing this. Flat bearings are provided with tapered gibs that are easily adjusted, and cylindrical bearings, like those of the spindle, have ready means of taking up wear. It is essential that any adjustment required be promptly

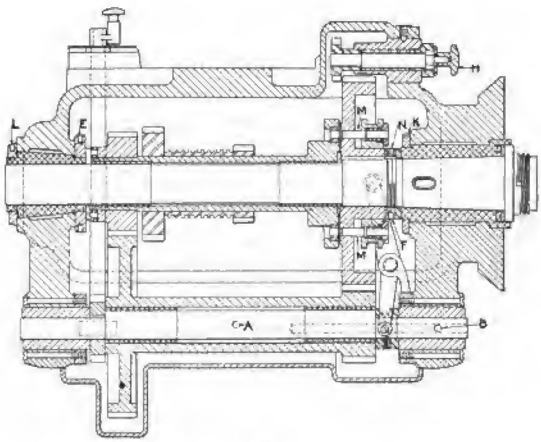


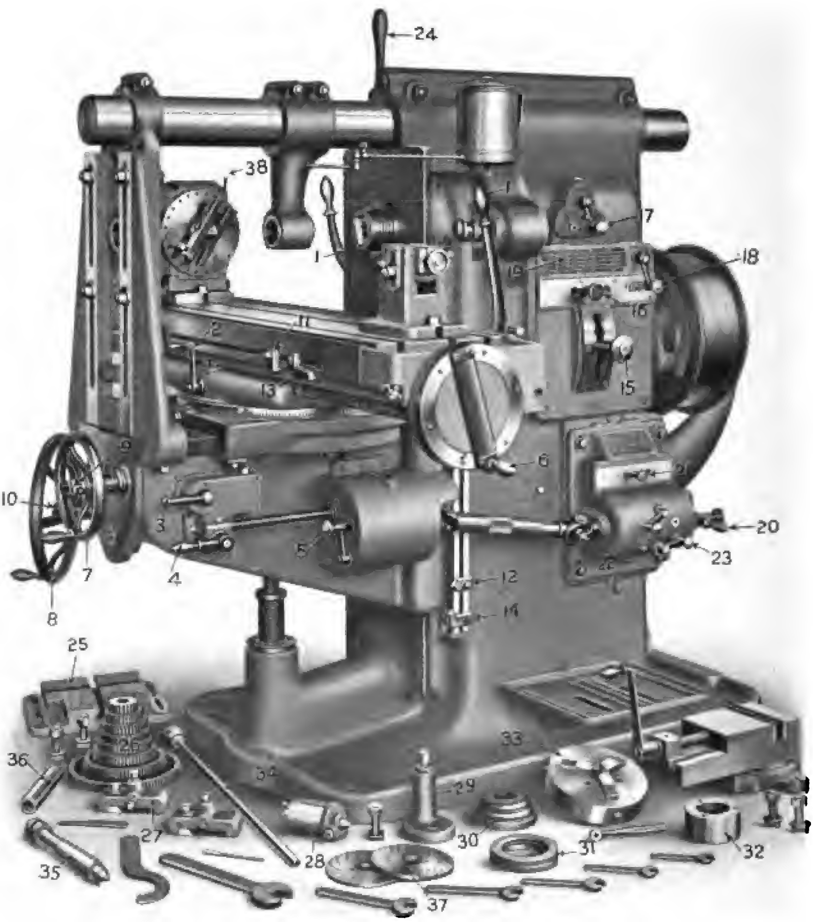
Fig. 3

made, for otherwise the accuracy of the machine is impaired. Furthermore, parts wear much more rapidly as the lost motion becomes greater. By a little examination and adjustment every now and then, the efficiency of a machine can be maintained and its life indefinitely prolonged.

Before proceeding to adjust or take anything apart, it is a good plan to carefully study its principle of construction. Many times this simple precaution will obviate considerable trouble.

The prevailing practice in designing spindle bearings is to have the front bearing on the spindle tapered and the rear bearing straight. On our machines the front bearing is adjusted by loosening check screw N and tightening nut F, Fig. 3. This draws the spindle back into the box, and as the bearing is tapered, the lost motion is taken up.

Should it become necessary, after running a machine for a number of years, to obtain more adjustment in this front box, the spindle can be removed and the washers between the spindle collar and the front of the box can be reduced a little in thickness. The adjusting nut F will then take care of the wear for another long period of time. Nut K should not be disturbed, as this merely holds the box in place. The rear box is split and fits in a taper hole in the frame. It is adjusted by loosening nut L and tightening nut E.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Explanation of Levers, Hand-wheels, etc., on Brown & Sharpe Constant Speed Drive Milling Machines

1. Friction clutch levers for starting and stopping machine.

1 2. Automatic feed trip and reverse lever for longitudinal movement of table.

2 3. Automatic feed trip lever for transverse movement of saddle.

4. Automatic feed trip lever for vertical movement of knee.

5. Lever for reversing all automatic feeds.

3 6. Hand-wheel for quick return of table.

4 7. Hand-wheel for transverse movement of saddle.

5 8. Hand-wheel for vertical movement of knee.

9 and 10. Knobs for disengaging hand-wheels.

11. Adjustable dog for controlling length of table movement.

12. Adjustable dog for controlling length of knee traverse.

13. Safety dog for preventing table running too far.

14. Safety dog for preventing knee running too far down.

15. Spindle drive tumbler gear lever.

16. Knob for sliding the tumbler gear.

17. Quill gear lever.

18. Back gear lever.

19. Index plate of spindle speeds.

20. Feed drive tumbler gear lever.

21. Knob for sliding the tumbler gear.

22 and 23. Levers for moving change gears.

7 24. Lever for clamping overhanging arm.

25. Raising block for spiral head.

26. Change gears for spiral head.

27. Table stops for preventing longitudinal table movement.

28. Adjustable centre.

29. Centre rest.

30. Arbor holding nut.

31. Guard nut for spindle threads.

32. Chuck plate for spindle.

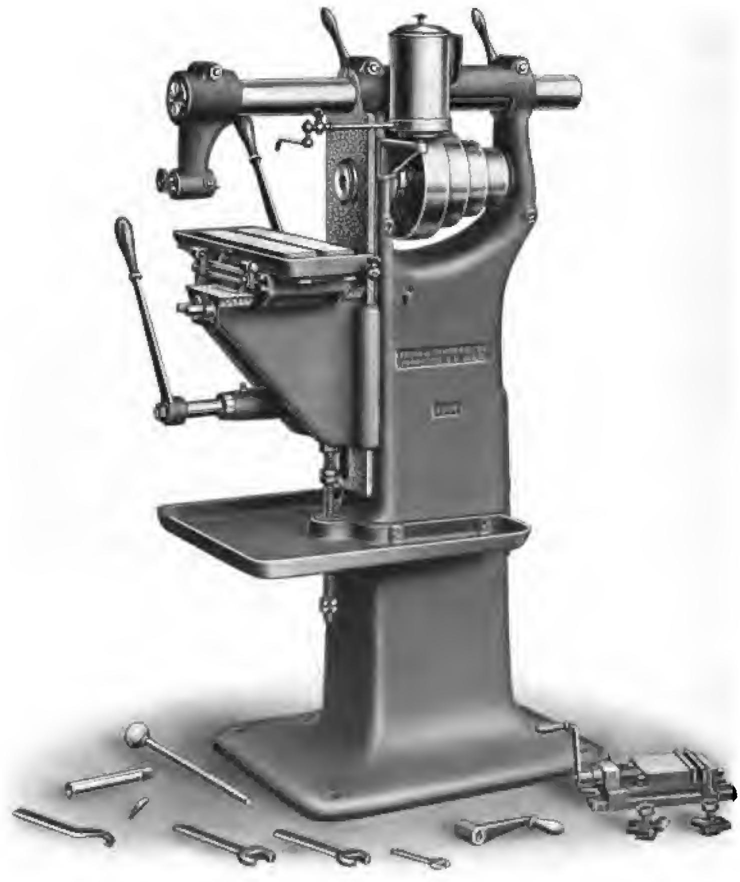
33. Chuck.

34. Knock-out rod for spindle.

35. Differential indexing centre.

36. Collet.

37. Index plates.

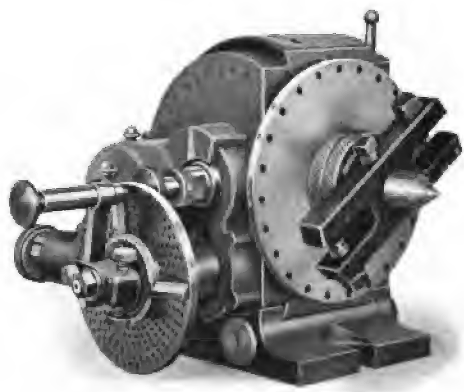


Hand Milling Machine

CHAPTER IV

Spiral Head—Indexing and Cutting Spirals

The mechanism known as the spiral head constituted one of the fundamental parts of the original universal milling machine. Its primary purpose was that of indexing and rotating work in conjunction with the movement of the table for cutting flutes in twist drills. The great possibilities it offered in cutting a large range of spirals, and for doing many other jobs, were soon recognized and developed, until it is now used for an endless variety of operations. With it, ordinary indexing to obtain even spacing on the periphery of pieces, as in cutting teeth in cutters, ratchets, clutch gears, gear wheels and flutes in reamers, taps, drills, etc., can be quickly accomplished. Spiral forms of all common leads can be accurately reproduced by its use.



Spiral Head

The spiral head and foot-stock are furnished as a part of all universal milling machines and can be applied, with few exceptions, to plain and vertical spindle machines. Used in connection with a vertical spindle milling attachment, on a plain machine, much the same variety of work can be done as on the universal.

In construction, spiral heads of today embody the same principles as the one on the original universal milling machine, but improvements have made them more solid and convenient to operate. Likewise, improvements have been made in the design and construction of the foot-stock.

Since our spiral head is typical of these mechanisms, a description of its various points may aid in understanding the methods of indexing and cutting spirals. The head itself consists of a hollow, semi-circular

casting in which is mounted a spindle that is connected to an index crank through a worm and wheel. Fig. 4 shows the construction of this part. The head casting has dove-tailed bearings at each side that fit the contour of a base plate, which can be clamped to the surface of the table. The alignment of the head with the table longitudinally is provided by means of a tongue on the under side of the base plate that fits a T slot in the table.

The spiral head spindle passes through the head, and is held in place by means of a nut at the small end. The front end is threaded and has a taper hole corresponding to that of the machine spindle.

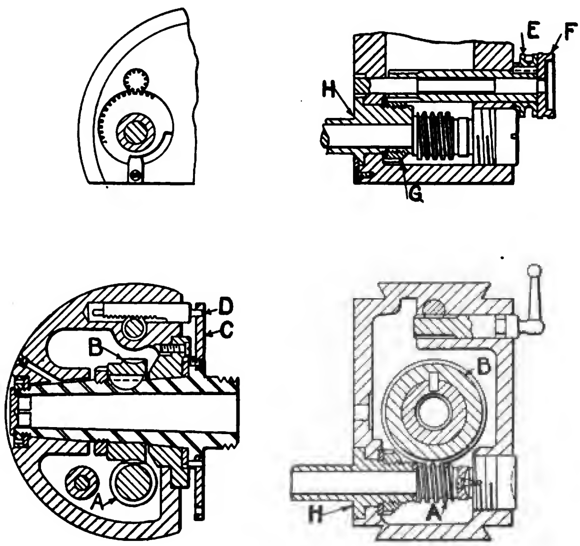


Fig. 4

It is rotated by means of the worm wheel B, which is driven by the hardened worm A that is located on the shaft to which the index crank is fastened. In order to insure accuracy the worm threads are ground after hardening. Through gearing, the index plate and worm A can be driven together from the table feed screw when the index pin is in position in any hole of a plate. When worm A is turned by means of the index crank, indexing may be accomplished, and when it is geared to the table feed screw, spiral milling, in addition to indexing, is made possible. The cutting of the spiral is due to the turning of the table feed screw, which through the interposition of change gears between this screw and the gears that drive the shaft carrying worm A, causes the spindle of the spiral head to rotate as

the table advances, so that the cutter produces a spiral cut in the work. For rapid indexing, when cutting flutes in taps, reamers, etc., the worm A is disengaged and the spindle turned by hand, the divisions being made by means of the index plate C, which is fastened to the nose of the spindle, and may be locked by the pin D.

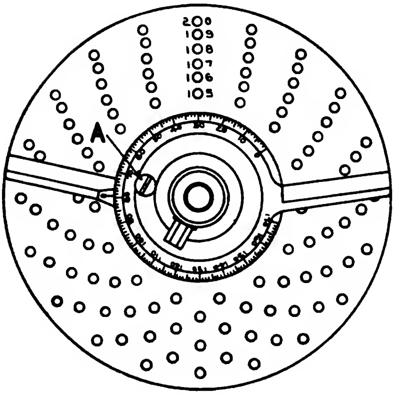


Fig. 5

The spindle may be revolved continuously as when cutting spirals, or may be securely locked after being revolved a desired amount, as in indexing for cutters, the teeth of gears, clutches, ratchets, etc.

It is possible to swing the head in its bearings so that the front end of the spindle can be set to any desired angle from 10° below the horizontal to 5° beyond the perpendicular without throwing the driving members out of mesh. Graduations on the front edge of the head indicate the angle of elevation to half degrees.

The design of the head is such that it permits unusually long and wide bearings. Furthermore, it sets very low and can be so firmly clamped to the base that the whole mechanism practically becomes one solid casting. Hence, it provides a particularly rigid support for the work, and that is a factor of much importance in the class of work that is done upon this mechanism.

Index Plates and Change Gears. Three index plates are furnished with the spiral head, and contain circles with the following numbers of holes:—

Plate 1—15, 16, 17, 18, 19, 20.
Plate 2—21, 23, 27, 29, 31, 33.
Plate 3—37, 39, 41, 43, 47, 49.

The change gears that are furnished have the following numbers of teeth: 24 (2 gears), 28, 32, 40, 44, 48, 56, 64, 72, 86, and 100.

Graduated Index Sector. Without the graduated index sector, much care must be exercised in counting the holes in an index plate when indexing to obtain any given number of divisions. Such a sector enables the correct number of holes to be obtained at each indexing with little chance for error. It is shown in Fig. 5 and

consists of two arms which may be spread apart when the screw A is loosened slightly. The correct number of holes may be counted and the sector arms set to include them; or better, the graduations on the dial may be used in connection with the tables given on pages 208 to 216. To set the sector arms by this last method, follow down the column headed "Graduation" in the tables referred to, until opposite the number of divisions that is desired. Take the number that is found here and set the arms by bringing the left one against the index pin, which should be inserted in any convenient hole in the required circle, and moving the right one until the graduation corresponding to the number obtained from the table coincides with the zero on the left arm. The correct number of holes will then be contained between the two arms, and counting is unnecessary.

When setting the arms by counting the holes, the left arm should be brought against the index pin as directed above, and then the required number of holes for each division should be counted from the hole that the pin is in, considering this hole as zero.

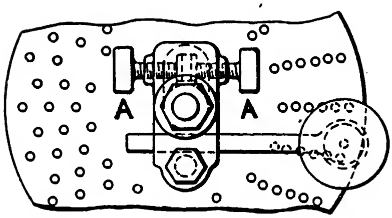


Fig. 6

Adjustable Index Crank. The index crank of the spiral head is adjustable circumferentially. This is shown in Fig. 6. Many times it is desired to make a delicate adjustment of the work, or to bring the index pin to the nearest hole without disturbing the setting of the work. To adjust the index crank after the work has been placed in position, turn thumb screws A-A, Fig. 6, until the pin enters the nearest hole in the index plate. To rotate the work relative to the index plate, both the stop pin at the back of the plate and the index crank pin should be engaged, the adjustment being made by means of the thumb screws as before.

Throwing Worm Out of Mesh. When it is desired to turn the spindle by hand and index work by means of the plate on the front end of the spindle, it is necessary to disengage the driving worm A, Fig. 4. To do this, turn the knob E, by means of a pin wrench furnished, about one-quarter of a revolution in the reverse direction to that indicated by an arrow stamped on the knob. This will loosen nut G that clamps eccentric bushing H; then with the fingers turn both knobs E and F, at the same time, and the bushing H will revolve,

disengaging the worm from the wheel. To re-engage the worm, reverse the above operation.

Effect of Change in Angle of Elevation on Spindle. If the angle of the spiral head spindle is changed during operation, the spindle must be rotated slightly to bring the work back to the proper position, for when the spindle is elevated or depressed, the worm wheel is rotated about the worm, and the effect is the same as if the worm was turned.

Foot-stock. The foot-stock shown in Fig. 7 is for supporting pieces of work that are milled on centres or the outer ends of arbors, and pieces that are clamped in a chuck. The centre is adjustable longitudinally, and can be elevated or depressed by means of a rack V, and pinion actuated by hex U. It can also be set at an angle out of parallel with the base when it is desired to mill drills, taper reamers, etc., so that it can be kept in perfect alignment with the spiral head

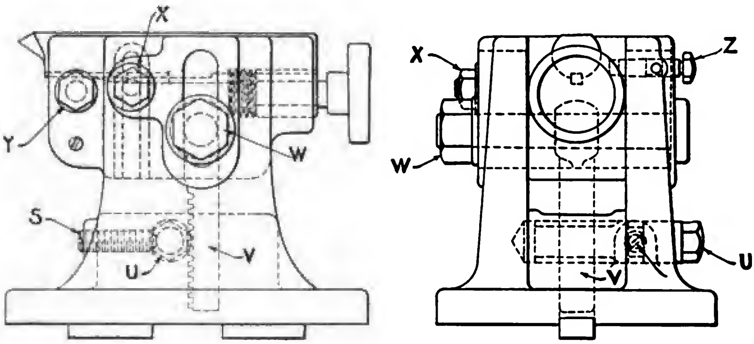


Fig. 7

centre. The advantage of this is readily appreciated from the fact that by the use of centres that cannot be adjusted, work is apt to become cramped at certain positions during its revolution, and, as a result, even spacing cannot be obtained.

When set in any position, the centre is firmly held by means of the nuts W, X and Y. Set Screw S prevents endwise movement of the elevating pinion.

Two taper pins, one of which is shown at Z, are used to quickly and accurately locate the foot-stock centre in line with the spiral head centre, when the centres are parallel to the top of the table. They may be loosened by twisting a little with a wrench.

Fig. 8 shows a gauge that is very handy to use for quickly adjusting the foot-stock centre in line with the spiral head centre

when setting for taper work. It consists of a bushing that fits over the centre in the spiral head and a blade, the bottom edge of which is the same distance above the centre as the top of the foot-stock centre.

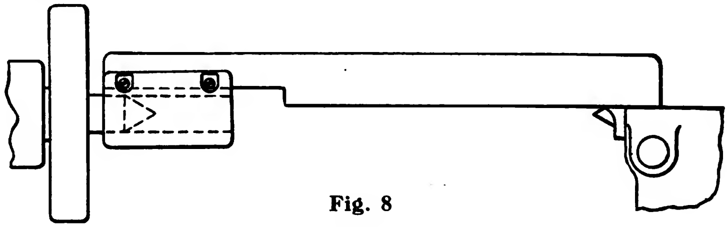


Fig. 8

INDEXING

The first office of the spiral head is to index or divide the periphery of a piece of work into a number of definite or given parts. This is accomplished by means of the index crank and the index plates furnished with the head; or, in the case of some of the more common coarse divisions, by means of the rapid index plate fastened to the nose of the spindle.

There are two practical and accurate methods of indexing, known as Plain and Differential. A third method, known as the Compound, was used extensively in the past, and is still employed by some shops having machines that are not fitted for Differential indexing. The chances for errors in making the complicated indexing moves, and the fact that even when the moves are made correctly, exact results cannot be obtained, causes the Compound method to be of little practical value where accurate spacing is required. It has, as a result, been largely superseded by the Differential method, by which the same numbers can be indexed accurately, and with little liability of errors in making the indexing moves.

Most spiral heads that are not fitted for Differential indexing can be at a nominal cost, and the unusual simplicity and convenience of this method in themselves are sufficient to warrant doing this.

By the Plain method of indexing, which includes rapid indexing, using the plate on the spindle nose, all divisions up to 50, even numbers up to 100, except 96, and many numbers that are multiples of 5 up to 380, besides many others, can be indexed with the three index plates furnished. With the addition of the change gears furnished, divisions obtained by Plain indexing, together with those that cannot be obtained by that method, from 1 to 382, and many others beyond, can be indexed by the Differential method.

Plain and Direct Indexing. Plain indexing on the spiral head is very similar to indexing with ordinary index centres. It depends entirely upon how many times the index crank must be turned to cause the work to make one revolution. When this ratio is known, it is an easy matter to calculate the number of turns or fractions of a turn of the index crank to produce a given number of spaces on the periphery of the work.

The worm wheel on the spindle contains 40 teeth and the worm is single threaded, hence for every turn of the index crank, the worm wheel is advanced one tooth, or the spindle makes $\frac{1}{40}$ part of a revolution. This should be remembered, for it is used in all indexing calculations on the spiral head. If the crank is turned 40 times, the spindle and work will make one complete revolution. To find how many turns of the crank are necessary for a certain division of the work, 40 is divided by the number of the divisions which are desired. The quotient will be the number of turns, or the part of a turn of the crank, which will give each desired division. Applying this rule, 40 divisions would be made by turning the crank completely around once for each division, or 20 divisions would be obtained by turning around twice. When the quotient contains a fraction, or is a fraction, it will be necessary to give the crank a part revolution in indexing. The numerator of the fraction represents the number of holes that should be indexed for each division. If the fraction is so small that none of the plates contains the number of holes represented by the denominator, both numerator and denominator should be multiplied by a common multiplier that will give a fraction, the denominator of which represents a number of holes that is available. On the other hand, if the fraction is of large terms, it should be reduced so that its denominator will represent a number of holes that is available. For example, seven divisions are desired. 40 divided by 7, equals $5\frac{5}{7}$ turns of the index crank to each division. There is no plate containing so few holes as 7, so this should be raised. Multiplying by the common multiplier 3, we have $\frac{5}{7} \times \frac{3}{3} = \frac{15}{21}$. Hence, for one division of the work, the index crank pin is placed in the 21 hole circle, and the crank is given 5 complete revolutions and then is moved ahead 15 additional holes. 35 holes in the 49 hole circle might also be used in place of 15 in the 21 hole circle, as $\frac{35}{49}$ is a multiple of the original fraction $\frac{5}{7}$.

The tables on pages 208 to 216 give the correct circles of holes and numbers to index for each division of all numbers that are obtainable by plain indexing, as well as those obtainable by the differential

method, and when these are used figuring, such as that above, is unnecessary.

Indexing in Degrees and Parts of Degrees. When it is desired to divide the circumference of a piece in this manner, it can often be done by plain indexing. One complete turn of the index crank produces $\frac{1}{40}$ of a turn of the work, or $\frac{360°}{40} = 9$ degrees. Following this method:

2 holes in the 18-hole circle = 1 degree.
2 holes in the 27-hole circle = $\frac{2}{3}$ degree.
1 hole in the 18-hole circle = $\frac{1}{2}$ degree.
1 hole in the 27-hole circle = $\frac{1}{3}$ degree.

Other odd fractional parts of a degree can be easily found by dividing the number of holes in any given circle into 9 degrees. It will be noticed that $\frac{1}{4}$ degree spacing cannot be obtained in this way; but with differential indexing, as explained on page 57, it is easy to get $\frac{1}{4}$ degree and other fractional spacings.

Differential Indexing. Differential indexing enables a wide range of divisions to be indexed. With the change gears and three index plates furnished with the spiral head, it is possible to index all numbers, not obtainable by plain indexing, from 1 to 382; in addition, many other divisions beyond 382 can be indexed.

Spiral Head Geared for Differential Indexing

By this method, the index crank is moved in the same circle of holes, and the operation is like that of plain indexing. The spiral head spindle and index plate are connected by a train of gearing, as shown above, and the stop pin at the back of the plate is thrown out. As the index crank is turned, the spindle is rotated and the plate moves either in the same or opposite direction to that of the crank. The total movement of the crank at every indexing is, therefore, equal to its movement relative to the plate, plus the movement of the plate, when the plate revolves in the same direction as the crank, or minus the movement of the plate,

when the plate revolves in the opposite direction to the crank. The spiral head cannot be used for cutting spirals, when it is geared for differential indexing, for when cutting spirals the head is geared to the table feed screw.

To obviate the necessity of figuring out the change gears every time a certain number of divisions is required, tables on pages 208 to 223 have been compiled. By use of these tables, all numbers obtainable by differential indexing, together with those that can be had by the plain method can be easily indexed. The tables also give the correct circle and number of holes to be indexed, graduations for setting of the index sector, and the proper change gears to use.

In order to select the proper change gears, it is first necessary to find the ratio of the required gearing between the spindle and plate. After this has been done, the correct gears can be found. The following formulae show the manner in which this gearing is calculated.

N = number of divisions required.

H = number of holes in index plate.

n = number of holes taken at each indexing.

V = ratio of gearing between index crank and spindle.

x = ratio of the train of gearing between the spindle and the index plate.

$\left.\begin{array}{l} S = \text{gear on spindle.} \\ G_1 = \text{first gear on stud.} \end{array}\right\}$ Drivers.

$\left.\begin{array}{l} G_2 = \text{second gear on stud.} \\ W = \text{gear on worm.} \end{array}\right\}$ Driven.

$$x = \frac{HV-Nn}{H} \text{ if } HV \text{ is greater than } Nn.$$

$$x = \frac{Nn-HV}{H} \text{ if } HV \text{ is less than } Nn.$$

$$x = \frac{S}{W} \text{ (for simple gearing.)}$$

$$x = \frac{S\,G_1}{G_2\,W} \text{ (for compound gearing.)}$$

V is equal to 40 on the B. & S. spiral head, and the index plates furnished have the following numbers of holes: 15, 16, 17, 18, 19, 20, 21, 23, 27, 29, 31, 33, 37, 39, 41, 43, 47, 49.

The gears furnished have the following numbers of teeth: 24 (2 gears), 28, 32, 40, 44, 48, 56, 64, 72, 86, 100.

In selecting the index circle to be used, it is best to select one with a number having factors that are contained in the change gears

on hand, for if H contains a factor not found in the gears, x cannot usually be obtained, unless the factor is canceled by the difference between HV and Nn, or unless N contains the factor.

When HV is greater than Nn and gearing is simple, use 1 idler.

When HV is greater than Nn and gearing is compound, use no idlers.

When HV is less than Nn and gearing is simple, use 2 idlers.

When HV is less than Nn and gearing is compound, use 1 idler.

Select "n" so that the ratio of gearing will not exceed 6:1 on account of the excessive stress upon the gears.

A few examples are given herewith to illustrate the application of the above formulae:

Example 1:

$N=59$. Required H, n and x.

Assume $H=33$, $n=22$.

Then $x=\dfrac{(33\times 40)-(59\times 22)}{33}=\frac{22}{33}=\frac{2}{3}$.

We now select gears giving this ratio, as 32 and 48, the 32 being the gear on spindle and the 48 the gear on worm. HV is greater than Nn, and the gearing is simple, requiring 1 idler.

Example 2:

$N = 319$. Required H, n and x.

Assume $H=29$, $n=4$.

Then $x=\dfrac{(319\times 4)-(29\times 40)}{29}=\frac{116}{29}=\frac{4}{1}$.

When the ratio is not obtainable with simple gearing, try compound gearing.

$\frac{4}{1}$ can be expressed as follows:

$$\frac{3\times 4}{1\times 3} \text{ or } \frac{72\times 64}{24\times 48}$$

for which there are available gears.

HV is less than Nn and the gearing is compound, requiring one idler.

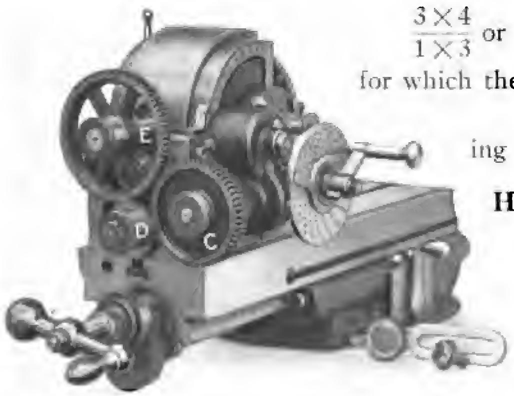


Fig. 9

Head Geared for 271 Divisions

Fig. 9 shows the spiral head geared, simple gearing, for 271 divisions. Referring to the table on page 214, the gears called for are: C, 56 teeth, and E, 72 teeth, with

one idler D. The idler D serves to rotate the index plate in the same direction as the crank, thus in making 280 turns of the crank, nine divisions are lost, giving the correct number of divisions, 271. The sector should be set to indicate $\frac{1}{7}$ turns, or 3 holes in the 21 hole circle, and the head is ready for 271 divisions, the indexing being made the same as for plain indexing.

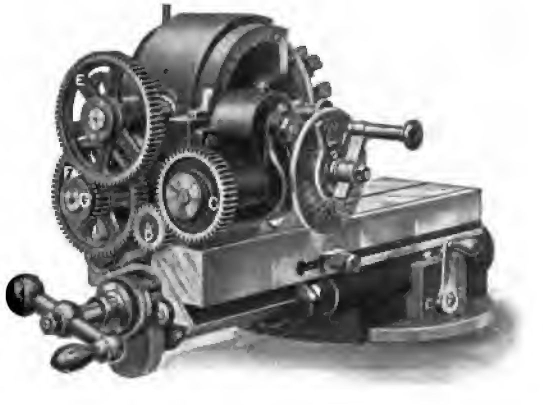


Fig. 10

Head Geared for 319 Divisions.

Fig. 10 shows the spiral head geared, compound gearing, for 319 divisions. Referring to the table on page 215, the gears called for are: C, 48 teeth; F, 64 teeth; G, 24 teeth; E, 72 teeth and one idler D, 24 teeth. The sector should be set to $\frac{4}{29}$ turns, or 4 holes in the 29 circle; the head is then ready for 319 divisions.

Spacing for Quarter Degrees.

Example 3.

Required H, n and x for spacing $\frac{1}{4}$ degrees, or 1440 divisions.

Assume $H=33$, $n=1$.

Then $\frac{(1440\times1)-(33\times40)}{33}=\frac{120}{33}$ or $\frac{64\times100}{40\times44}$

One idler is required.

The following table gives data required for spacing $\frac{1}{4}°$ and $\frac{1}{6}°$. For fractional parts of degrees obtainable by plain indexing see page 54.

Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2d Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
$\frac{1}{6}°$	49	$\frac{1}{49}$		28	64	56	100		24
$\frac{1}{4}°$	33	$\frac{1}{33}$		44	64	40	100		24

Aliquant or Fractional Spacing.

Example 4:

Required: A Vernier to read to $\frac{1}{12}$ degree or five minutes, the scale being divided to degrees.

Each Vernier space can equal $\frac{11}{12}$ degree.

$$\frac{11\times 1}{12\times 360}=\frac{11}{4320} \text{ or } \frac{4320}{11} \text{ spaces in whole circle} = 392\tfrac{8}{11} \text{ spaces.}$$

Assume $H=18$, $n=2$.

$$\text{Then } \frac{(392\frac{8}{11}\times 2)-(18\times 40)}{18}=\frac{720/11}{18}=\frac{720}{11}\times\frac{1}{18}=\frac{40}{11}=\frac{64\times 100}{40\times 44}$$

One idler is required.

CUTTING SPIRALS.

Spirals that are most commonly cut on milling machines embrace spiral gears, spiral mills, counterbores, and twist drills. Worms are also cut with the aid of a vertical spindle or universal milling attachment. Examples of some of these classes of work are shown in this chapter; and in operations in chapters VIII and IX.

The method of producing the spiral movement of the work has been described before, and the manner in which the head is geared is shown in Figs. 11 and 12. The four change gears are known as: *gear on screw; first gear on stud (as it is the first to be put on); second gear on stud; and gear on worm.* The screw gear and first gear on stud are the drivers, and the others are the driven gears. By using different combinations of the change gears furnished, the ratio of the longitudinal movement of the table to the rotary movement of the work can be varied; in other words, the leads of the spirals it is possible to cut are governed directly by these gears. Usually they are of such ratio that the work is advanced more than an inch while making one turn, and thus the spirals cut on milling machines are designated in terms of inches to one turn, rather than turns, or threads per inch; for instance, a spiral is said to be of 8 inches lead, not that its pitch is 1-8 turn per inch.

The feed screw of the table has four threads to the inch, and forty turns of the worm make one turn of the spiral head spindle; accordingly, if change gears of equal diameter are used, the work will make a complete turn while it is moved lengthwise 10 inches; that is, the spiral will have a lead of 10 inches. This is the lead of the machine, and it is the resultant of the action of the parts of the machine that are always employed in this work, and is so regarded in making the calculations used in cutting spirals.

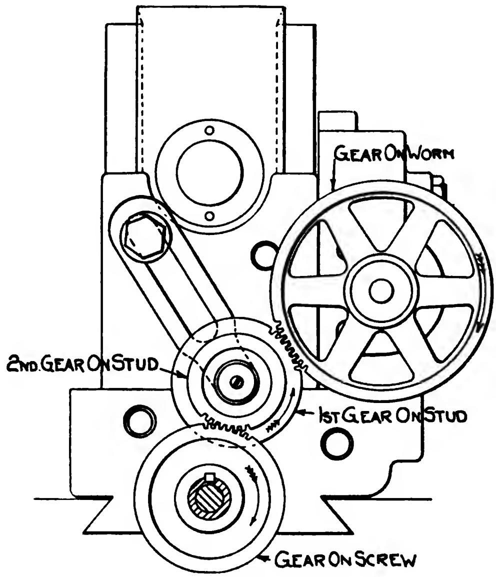


Fig. 11

Showing Gearing When No Idler is Required

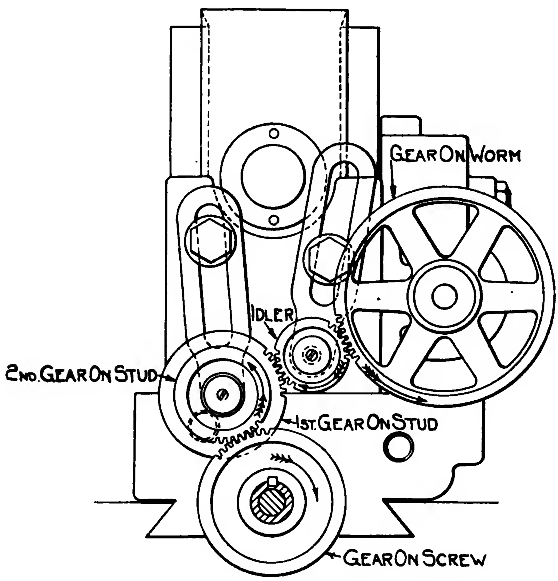


Fig. 12

Showing Gearing With Idler in Use

Principle same as for Change Gears of a Lathe. In principle, these calculations are the same as for change gears of a screw cutting lathe. The compound ratio of the driven to the driving gears equals in all cases, the ratio of the lead of the required spiral to the lead of the machine. This can be readily demonstrated by changing the diameters of the gears.

Gears of the same diameter produce, as explained above, a spiral with a lead of 10 inches, which is the same lead as the lead of the machine. Three gears of equal diameter and a driven gear double this diameter, produce a spiral with a lead of 20 inches, or twice the lead of the machine; and with both driven gears, twice the diameters of the drivers, the ratio being compound, a spiral is produced with a lead of 40 inches, or four times the machine's lead. Conversely, driving gears twice the diameter of the driven produce a spiral with a lead equal to $\frac{1}{4}$ the lead of the machine, or $2\frac{1}{2}$ inches.

Expressing the ratios as fractions, the

$$\frac{\text{Driven Gears}}{\text{Driving Gears}} = \frac{\text{Lead of Required Spiral}}{\text{Lead of Machine}}$$

or, as the product of each class of gears determines the ratio, the head being compound geared, and as the lead of the machine is ten inches, the $\frac{\text{Product of Driven Gears}}{\text{Product of Driving Gears}} = \frac{\text{Lead of Required Spiral}}{10}$ That is, the compound ratio of the driven to the driving gears may always be represented by a fraction whose numerator is the lead to be cut and whose denominator is 10. In other words, the ratio is as the required lead is to 10; for example, if the required lead is 20, the ratio is 20:10. To express this in units instead of tens, the ratio is always the same as one-tenth of the required lead is to 1. And frequently this is a very convenient way to think of the ratio; for example, if the lead is 40, the ratio of the gears is 4:1. If the lead is 25, the gears are 2.5:1, etc.

To illustrate the usual calculations assume that a spiral of 12 inch lead is to be cut. The compound ratio of the driven to the driving gears equals the desired lead divided by 10, or it may be represented by the fraction $\frac{12}{10}$. Resolving this into two factors to represent the two pairs of change gears, $\frac{12}{10} = \frac{3}{2} \times \frac{4}{5}$. Both terms of the first factor are multiplied by such a number (24 in this instance) that the resulting numerator and denominator will correspond with the number of teeth of two of the change gears furnished with the machine (such multiplications not affecting the value of a fraction) $\frac{3}{2} \times \frac{24}{24} = \frac{72}{48}$. The second factor is similarly treated: $\frac{4}{5} \times \frac{8}{8} = \frac{32}{40}$, and the gears with

72 and 32 and 48 and 40 teeth are selected. $\frac{12}{10} = \left(\frac{72 \times 32}{48 \times 40}\right)$ The first two are the driven, and the last two the drivers, the numerators of the fractions representing the driven gears. The 72 is the worm gear, 40 the first on stud, 32 the second on stud and 48 the screw gear. The two driving gears might be transposed, and the two driven gears might also be transposed without changing the spiral. That is, the 72 could be used as the second on stud and the 32 as the worm gear, if such an arrangement was more convenient. The following rules express in abridged form the methods of figuring change gears to cut given spirals, and of ascertaining what spirals can be cut with change gears.

Rules for Obtaining Ratio of the Gears Necessary to Cut a Given Spiral. Note the ratio of the required lead to 10. This ratio is the compound ratio of the driven to the driving gears. Example: If the lead of required spiral is 12 inches, 12 to 10 will be the ratio of the gears.

Or, divide the required lead by 10 and note the ratio between the quotient and 1. This ratio is usually the most simple form of the compound ratio of the driven to the driving gears. Example: If the required lead is 40 inches, the quotient $40 \div 10$ and the ratio 4 to 1.

Rule for Determining Number of Teeth of Gears Required to Cut a Given Spiral. Having obtained the ratio between the required lead and 10 by one of the preceding rules, express the ratio in the form of a fraction; resolve this fraction into two factors, raise these factors to higher terms that correspond with the teeth of gears that can be conveniently used. The numerators will represent the driven and the denominators the driving gears that produce the required spiral. For example: What gears shall be used to cut a lead of 27 inches?

$$\tfrac{27}{10} = \tfrac{3}{2} \times \tfrac{9}{5} = \left(\tfrac{3}{2} \times \tfrac{16}{16}\right) \times \left(\tfrac{9}{5} \times \tfrac{8}{8}\right) = \frac{48 \times 72}{32 \times 40}$$

From the fact that the product of the driven gears divided by the product of the drivers equals the lead divided by 10, or one-tenth of the lead, it is evident that ten times the product of the driven gears divided by the product of the drivers, will equal the lead of the spiral. Hence the rule:

Rule for Ascertaining what Spiral May be Cut by Any Given Change Gears. Divide ten times the product of the driven gears by the product of the drivers, and the quotient is the lead of the resulting spiral in inches to one turn. For example: What spiral

will be cut by gears, with 48, 72, 32 and 40 teeth, the first two being used as driven gears? Spiral to be cut equals $\frac{10 \times 48 \times 72}{32 \times 40} = 27$ inches to one turn.

This rule is often of service in determining what spirals may be cut with the gears the workman chances to have at hand.

The tables on pages 224 to 226 give the leads and approximate angles of some spirals produced by the gears furnished with our machines, and the combination of gears given in each case is such that they will properly mesh with one another. The tables on pages 227 to 245 contain all the leads that can be obtained with any possible combination of the change gears furnished, even though some of the leads are not available for use on account of the gears interfering or not reaching. Combinations of gears that are too small in diameter to reach for right-hand spirals, can generally be used for left-hand spirals, as the reverse gear is then required and will enable the gears to reach.

As we have already mentioned, the two driving gears, or the two driven gears of any combination can be transposed, but a driver must not be substituted for a driven or vice versa. Four different arrangements of the gears of any combination are thus possible, without changing the ratio, and when one arrangement interferes, or will not reach, the others should be tried. Thus, the gears to give a lead of 3.60″ are: drivers, 100 teeth and 32 teeth; driven, 24 teeth and 48 teeth. By transposing the gears, the following four arrangements may be obtained.

	1st	2nd	3rd	4th
Drivers.				
Gear on Screw	100	32	100	32
1st Gear on Stud	32	100	32	100
Driven.				
2nd Gear on Stud	24	24	48	48
Gear on Worm	48	48	24	24

The first arrangement, however, is found by actual test to be the only one available, owing to the interference of the gears in the other combinations preventing their meshing properly.

When very short leads are required, it is preferable to disengage the worm wheel and connect the gearing directly to the spiral head spindle (using the short lead spiral attachment shown in the next chapter, or the differential indexing centre). Either of these methods gives leads one-fortieth of the leads given in the table for the same combinations

of gears. Thus, for a lead of 6.160″, the table calls for gear on worm, 56 teeth, 1st gear on stud, 40 teeth; 2nd gear on stud, 44 teeth; and gear on screw, 100 teeth. Putting the 56 tooth gear on the spindle instead of on the worm, gives a lead of $\frac{6.160}{40} = .154''$.

By either method, very short leads may be obtained without excessively straining the mechanism, but the regular means of indexing the work cannot be employed. An index plate is provided on the short lead spiral attachment. A method that can be used for indexing

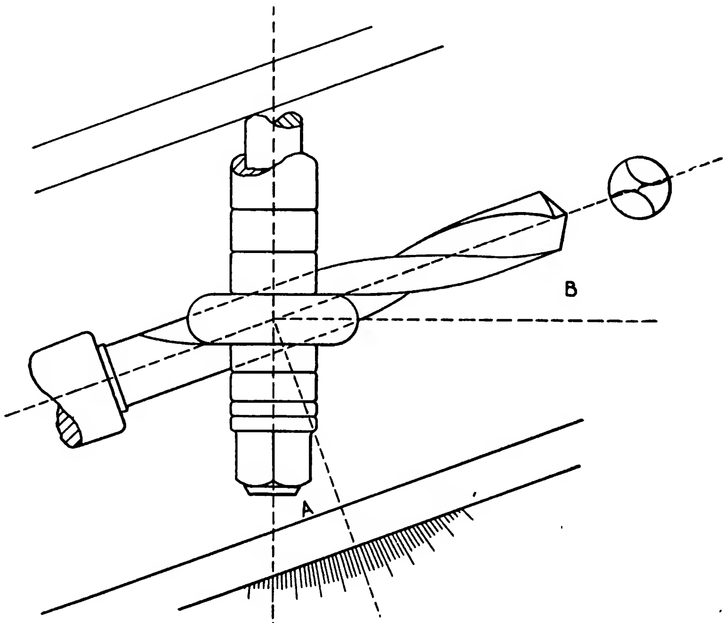
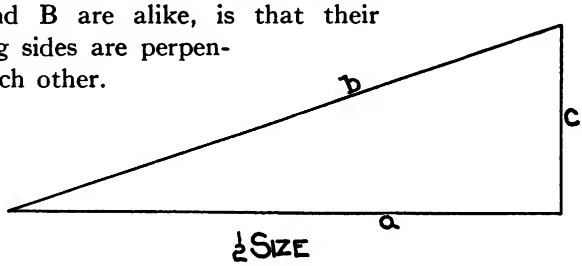


Fig. 13

when using the differential centre is to have the number of teeth in the gear on the spindle some multiple of the number required to be indexed. Swing the gears out of mesh and advance the gear on spindle the number of teeth required to index the work one division at each indexing. Thus, if 9 divisions are required with a lead of .261″, we select a lead from the table equal to about $.261'' \times 40 =$ 10.440″, when the gear on worm (which will now be the gear on spindle) is some multiple of 9, as 72. The nearest lead is 10.467″, which gives $\frac{10.467}{10} = .2617''$ lead, giving an error of .0007″. To index the work, the gear on spindle is advanced $\frac{72}{9} = 8$ teeth at each indexing.

Position of the Table in Cutting Spirals. The change gears having been selected, the next step in cutting spirals is to determine the position at which the table must be placed to bring the spiral in line with the cutter as the work is being milled.

The correct position of the table is indicated by the angle shown at A, Fig. 13, and this angle, as may be noticed from that figure, has the same number of degrees as the angle B, which is termed the angle of the spiral, and is formed by the intersection of the spiral and a line parallel with the axis of the piece being milled. The reason the angles A and B are alike, is that their corresponding sides are perpendicular to each other.



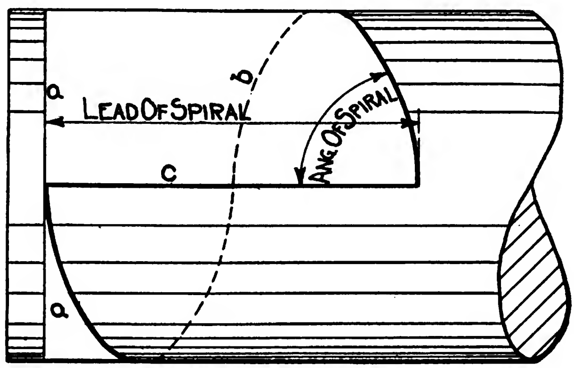


Fig. 14

The angle of the spiral depends upon the lead of the spiral and the diameter of the piece to be milled. The greater the lead of a spiral of any given diameter, the smaller the angle, and the greater the diameter of any spiral with a given lead, the greater the spiral angle.

If the angle wanted is not found in the tables on pages 224 to 226, it can be ascertained in two ways, graphically or more conveniently, by a simple calculation and reference to the tables on pages 307 to 315. In determining it graphically, a right-angle triangle is drawn to scale.

One of the sides which form the right angle represents the circumference of the piece in inches, and the hypothenuse represents the line of the spiral. The angle between the lines representing the path of the spiral and the lead of the spiral is the angle of the spiral. This angle can be transferred from the drawing to the work by a bevel protractor, or even by cutting a paper templet and winding it about the work as shown in Fig. 14. The machine is then set so that the spiral or groove as it touches the cutter will be in line with the cutter. Or the angle may be measured and the saddle set to a corresponding number of degrees by the graduations on the base.

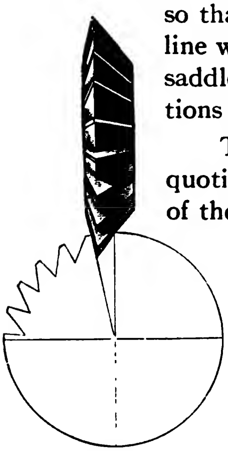


Fig. 15

The natural tangent of the angle of the spiral is the quotient of the circumference of the piece, divided by the lead of the spiral. Accordingly, the second method of obtaining the angle of the spiral is to divide the circumference of the piece by the lead, and note the number of degrees opposite the figures that correspond with the quotients in the tables of natural tangents, pages 307 to 315. The angle having been thus obtained, the saddle is set by the graduations on the base.

This second method is more satisfactory, as it is more accurate, and there is less liability of error than with the first. The saddle can be set to the proper angle, but before cutting into the blank, it is well to let the mill just touch the work, then run the work along by hand and make a slight spiral mark, and by this mark see whether the change gears give the right lead.

Special care should be taken in cutting spirals that the work does not slip, and when a cut is made it is well to drop the work away from the mill while coming back for another cut, or the mill may be stopped and turned to such a position that the teeth will not touch the work while the table is brought back preparatory to another cut.

Setting Cutter Centrally. In making such cuts as are alike on both sides, for instance, the threads of worms or the teeth of spiral gears, care must be taken to set the work centrally perpendicular with the centre line of the cutter before swinging the saddle to the angle of the spiral.

Cuts that have one face radial, especially those that are spiral, are best made with an angular cutter of the form shown in Fig. 15, as cutters of this form readily clear the radial face of the cut, keep sharp for some time and produce a smooth surface.

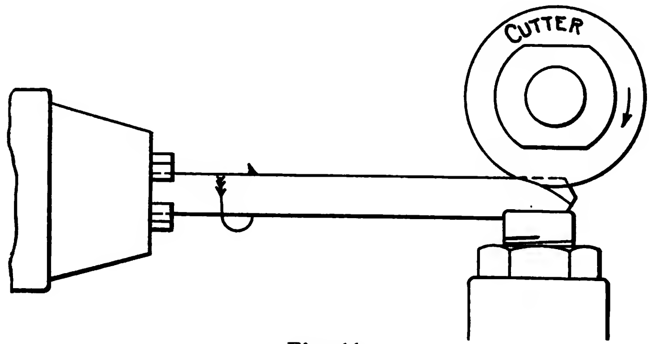


Fig. 16

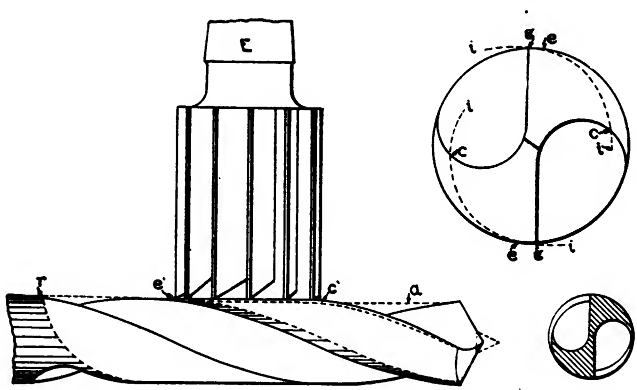


Fig. 17

Twist Drills. The operation of milling a twist drill is shown in Fig. 16. The drill is held in a collet, or chuck, and, if very long, is allowed to pass through the spindle of the spiral head. The cutter is brought directly over the centre of the drill, and the table is set at the angle of spiral.

The depth of groove in a twist drill diminishes as it approaches the shank, in order to obtain increased strength at the place where the drill generally breaks. The variation in depth is conditional; depending mainly on the strength it is desirable to obtain, or the usage the drill is subject to. To secure this variation in the depth of the groove, the spiral head spindle is elevated slightly, depending on the length of the flute and diameter of the drill.

The outer end of the drill is supported by the centre rest, and when quite small, should be pressed down firmly, until the cutter has passed over the end.

The elevating screw of this rest is hollow, and contains a small centre piece with a V groove cut therein to aid in holding the work central. This piece may be made in other shapes to adapt it to special work.

Another, and very important operation on the twist drill, is that of "backing off" the rear of the lip, so as to give it the necessary clearance, to prevent excessive friction during drilling. In the illustration, Fig. 17, the saddle is turned about one-half degree as for cutting a right-hand spiral, but as the angle depends on several conditions, it will be necessary to determine what the effect will be under different circumstances. A slight study of the figure will be sufficient for this, by assuming the effect of different angles, mills and the pitches of spirals. The object of placing the saddle at an angle is to cause the mill E to cut into the lip at c′, and have it just touch the surface at e′. The line r being parallel with the face of the mill, the angular deviation of the saddle is shown at a, in comparison with the side of the drill.

From a little consideration it will be seen that while the drill has a positive traversing and rotative movement, the edge of the mill at e′ must always touch the lip at a given distance from the front edge; this being the vanishing point, if such we may call it. The other surface forming the real diameter of the drill is beyond reach of the cutter, and is so left to guide and steady it while in use. The point e, shown in the enlarged section, shows where the cutter commences, and its increase until it reaches a maximum depth

at c, where it may be increased or diminished according to the angle employed in the operation, the line of cutter action being represented by ii.

Before backing off, the surface of the smaller drills in particular should be colored with a solution of sulphate of copper, water and sulphuric acid. This solution can be applied with a piece of waste, and will give the piece a distinct copper color. The object of this is to clearly show the action of the mill on the lip of the drill, for, when satisfactory, a uniform streak of coppered surface the full length of the lip from the front edge g back to e, is left untouched by the mill.

The above-mentioned coloring solution can be made by the following formula:

Sulphate of copper (saturated solution)	4 oz.
Water	8 oz.
Sulphuric acid	1 oz.

It is sometimes preferred to begin the cut at the shank end. By starting the cut in at this end, the tendency to lift the drill blank from the rest is lessened.

The table given on page 324 is useful for determining the cutters, pitches, gears and angles for twist drills.

Cutting Left-Handed Spirals. When giving directions for cutting spirals in any of the foregoing pages, right-hand spirals are at all times referred to. For the production of left-hand spirals, the only changes necessary are the swinging of the saddle to the opposite side of the centre line, and the introduction of an intermediate gear upon the stud, Fig. 12, to engage with either pair of change gears for changing the direction of rotation of the spiral head spindle.

Cutting Spirals with an End Mill. When spirals cannot be conveniently cut with side or angular milling cutters, as previously described, it is sometimes convenient to use end mills, as for example, when the diameter of the piece is very large, or the spiral is of such a lead that the table cannot be set at the requisite angle, the work is so held that its centre and that of the mill will be in the same plane and the saddle is set at zero.

CHAPTER V

Attachments

A milling machine is, in itself, a most versatile tool, but when equipped with a suitable set of attachments, the range of work that can be done is greatly increased. Also there are often milling operations that can be performed without an attachment, but by using one the jobs can be more easily and quickly done. Attachments are, therefore, most desirable auxiliaries where a machine is not confined to one manufacturing operation, but is used for general milling purposes. And even in manufacturing, where a machine is kept on one operation, an attachment can often be used to good advantage.

Broadly speaking, the variety of attachments for use on milling machines is almost limitless. To fully realize this, one has only to visit several shops producing different kinds of work on milling machines, and observe the methods employed. Devices of every conceivable description will be seen in use in connection with the machines, and, while many of them may be of a more or less special character and adaptable only to a particular operation, they are, strictly speaking, attachments. Some of these devices, however, are so designed that quite a number of different operations can be performed by their use, or the same operation can be repeated on a variety of pieces. It is these mechanisms that we are accustomed to regard more especially as attachments, while those designed for single operations are almost universally known in shops as fixtures. It would be useless to attempt to treat of the latter, as their designs and purposes are as varied as the different lines of mechanical work.

The efficiency of attachments, like machines, depends largely upon their design and construction, and a poorly designed or built mechanism of this type can seriously impair the quality of work and thus defeat its own object.

Many forms of attachments designed for the same purpose will be found, as it is necessary for every manufacturer to adapt attachments to his machine. This is a matter of minor importance, however, and a close examination will reveal that, as a general rule, the principles of the different mechanisms are similar. This chapter is devoted to

Fig. 18

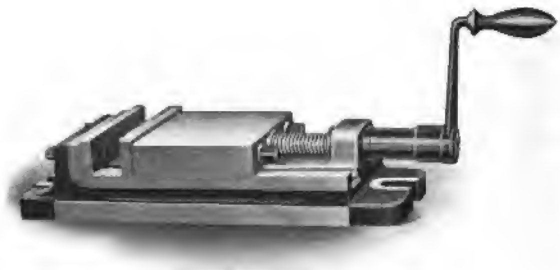


Fig. 19

Fig. 20

our line of attachments, as typical of attachments in general, with brief descriptions of their general designs and functions. From this information it is hoped that the reader will be able to understand the necessity for, and advantages of, these mechanisms.

Vises. While vises are furnished as a part of the regular equipment of most milling machines, and for that reason are not styled as attachments, notwithstanding this, they may be so properly classed.

Vises are useful for holding a large variety of small work while it is being milled or planed. Numerous illustrations of their employment can be found in the examples of operations throughout chapters VII and IX. It is essential that they be as rigid as possible, and to this end should be built with well-designed, strong, close-fitting parts. It is well to have them set low so as to bring the work close to the table.

There are several styles of vises. Fig. 18 shows a Plain Vise, for lighter operations. The bed and slide are of cast iron, while the jaws are tool steel, hardened and ground. It is fastened to the surface of the table by means of a screw that passes through the bed and threads into a nut inserted in a table T slot. The head of the clamping screw fits a counterbore in the vise bed, and is flush with the top of the casting, so that it does not interfere with the movement of the sliding jaw.

The vise shown in Fig. 19 is known as a Flanged Vise, and differs little from the Plain Vise except in the method of clamping to the table. A slotted flange is provided at each end for this purpose, and regular T slot bolts with nuts and washers are employed. Also a pair of straps are furnished for clamping the vise at the sides when this is necessary.

It is sometimes desired to mill angular or tapering work. A vise provided with a swivel, and known by that name, is shown in Fig. 20, and by its use this work can be readily done. The vise proper is of the same design as the plain vise, but the bottom of the bed fits into a split ring in a base. This ring is tapered on the inside to draw the bed to its seat, and holds it rigidly without disturbing the alignment. The split ring is closed by either one of the two clamping bolts at the side, two being provided for convenience in setting. The entire circumference of the base is graduated to degrees, and the vise can be readily swung to any angle to the table ways. The base is provided with flanges for fastening it to the surface of the table.

Fig. 21 shows a Tool-Makers' Universal Vise, designed to meet the requirements of tool-makers and machine shops where a great

variety of work is encountered. It is found of advantage for holding irregular or angular pieces and forms, also in determining and forming the edges for model parts of machines and work of a similar class. Often this vise will take the place of an expensive fixture. It can be set at any angle and the work placed in position or removed without disturbing the setting. It can also be easily removed from one machine to another and several operations performed without removing the piece of work. The base is double, and is fastened to the table by bolts, that fit into the table T slots. It has two sets of bolt slots to allow for moving the vise back when set in a vertical plane. The upper part is a hinged knee, that swivels on the lower part of the base, and it can be set at any angle in a horizontal plane, graduations to degrees indicating the position. The top section of the knee is hinged to the lower part in such a manner that it can be set at any angle to 90° in a vertical plane, and clamped rigidly in position by the nut on the end of the bolt forming the hinge and by the bolt at the joint in the bracing levers. Graduations on a steel dial at the side of the vise indicate the elevation of the knee. A swiveling movement is also provided for the vise proper on the upper part of the hinged knee, and it can be set and clamped at any angle to the axis of the bolt forming the hinges.

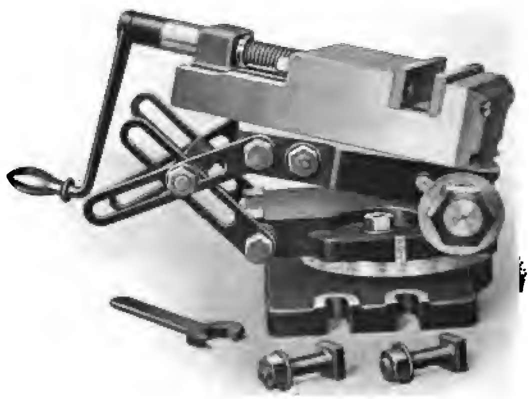


Fig. 21

Index Centres. These mechanisms are employed for obtaining exact spacing of more common numbers of divisions upon the periphery of pieces of work, such as in cutting the teeth of small gears, ratchets and cutters, fluting taps and reamers, milling the sides of nuts and heads of bolts, and various other purposes. They are used principally upon machines not fitted with a spiral head, for their functions in most instances can be equally well performed by the latter, which also offers many additional advantages.

Like other attachments, their efficiency is largely dependent upon their design, and it is important that they be exceedingly stiff,

in order that the work may be rigidly supported. They should also be convenient to operate, so that indexing may be quickly accomplished.

One of the simplest forms of index centres, known as Single Dial Index Centres, is shown in Fig. 22. It consists of a head-stock and foot-stock of solid construction. The spindle of the head-stock is turned by means of the hand-wheel, and the divisions are indicated on the periphery of an index plate fastened to the spindle near the hand-wheel. There are holes in the back of the index plate corresponding to the divisions on its periphery, and a hardened steel taper pin is provided that is forced into the bushings of these holes by a

Fig. 22

spring, efficiently locking the spindle at any one of the divisions. The small lever near the top of the head-stock withdraws the taper pin when it is desired to index the work.

This style of index centres is found convenient whenever rapid indexing is to be done, as in cutting teeth in sprocket wheels, mills, or in milling grooves in taps, reamers and work of a similar kind. They are built in two sizes, one to accommodate work up to 8 inches diameter, and the other for work up to 12 inches diameter. The index plates or dials furnished have 24 divisions, or holes, but special plates having, for 8 inch centres, any number of holes up to 32, and, for 12 inch centres, any number up to 32, are sometimes made to order.

A common style of index centres, known as Plain Index Centres, is shown in Fig. 23. The spindle of the head-stock is revolved by means of a worm and wheel. The handle of the crank fastened to the worm shaft constitutes an index pin, and indexing is accomplished by means of a plate drilled with circles of different numbers of holes into which the spring pin of the crank fits. Thus it will be seen that the principle of indexing with these centres is the same as with the spiral head. For rapid indexing of the coarser divisions, the worm can be thrown out of mesh with the wheel and the spindle turned by hand; a circle

Fig. 23

of holes in the back of the worm wheel rim, and an index pin at the top of the head-stock provide for indexing when this is done.

These centres are built in sizes to accommodate work up to 10 inches and 12 inches diameter respectively. The nose of the spindle is threaded to receive a face plate or chuck. They are fitted with index sectors similar to those of the spiral head, and the index crank is adjustable so that it can be brought to the nearest hole without disturbing the setting. The index plates furnished divide all numbers to 50 and all even numbers to 100, except 96.

Fig. 24 shows a pair of Universal Index Centres. The resemblance between them and the spiral head is marked; in fact, the foot-stock is identical with that furnished with the latter mechanism. All operations upon centres that do not require other than plain indexing and where there is no spiral to be cut, can be performed with these centres equally as well as with a spiral head.

These universal index centres are built in six sizes, to accommodate work up to 6, 10, 12, 12½, 14 and 15 inches diameter. Divisions are indexed by means of the index crank and plates, the same

Fig. 24

as on the spiral head. The two smaller sizes are arranged for rapid indexing of coarser divisions by disengaging the worm, and indexing with the plate fastened directly to the nose of the spindle, as on the spiral head. The index crank is adjustable and index sectors are employed. The index plates furnished with the 6 inch and 10 inch centres divide all numbers to 50, and all even numbers to 100, except 96; those furnished with the 12½ inch centres divide all numbers to 100 and all even numbers to 134.

Index centres designed for manufacturing purposes where economy and rapidity of production are important factors, often have more than one spindle. Fig. 25 shows triple centres of this type. All three spindles of these centres are indexed simultaneously, and one thumb screw firmly clamps them all, consequently three pieces of work can

Fig. 25

be finished in practically the same time it takes to machine one on single centres.

The spindles are rotated by a ratchet operated by the lever shown at the left of the head-stock. Indexing is accomplished by an index plate which divides all numbers as follows: 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 20, and 24. The index stop pin is shown at the left of the head-stock.

Using all three spindles, work up to 2½ inches diameter can be taken; when only the two outside spindles are employed, work up to 5 inches diameter will swing.

Triple index centres of the design that has the index plate at the side of the head-stock similarly to the spiral head are shown in Fig. 26. Centres of this same general design, but arranged for rapid indexing only, are also built.

The index plates furnished with these centres divide all numbers to 50, even numbers to 100, except 96. When rapid indexing is desired, the worm of the index crank is disengaged and the centres are turned by means of a pinion actuated by the crank at the left of the head-stock; an index plate and stop pin provide for the divisions.

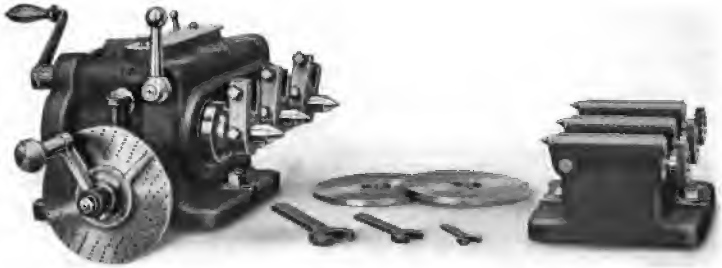


Fig. 26

The centres swing, using three spindles, 4 inches; using the two outside spindles, 8 inches.

Gear Cutting Attachment. The gear cutting attachment shown in Fig. 27 is useful for cutting spur gears of all diameters up to and including 16 inches, and is similar to ordinary index centres only in

Fig. 27

that it will swing larger diameters. It is exceptionally rigid in construction and, to further insure steadiness to the gear while being cut, an adjustable rim rest is placed on the head-stock.

The worm and wheel of this attachment are accurately cut, and the wheel is of much larger diameter than that of ordinary index centres; consequently the possibility for error in spacing is materially lessened. The worm and worm wheel can be disengaged and the spindle turned by hand by means of the handle at the back, when setting or testing work.

The index plates furnished divide all numbers to 100, all even numbers to 134, and all numbers divisible by 4 to 200.

In addition to cutting gears, this attachment may be used on jig work where accurate indexing is an essential element. The spindle is threaded for the purpose of holding a chuck or face plate.

Vertical Spindle Milling Attachments. Vertical spindle milling attachments, including the Compound and Universal types, are used for a wide range of light and heavy milling, such as key seating, T slot cutting, spiral milling, face milling and work of a similar class; in fact, almost any operation that can be performed with a vertical spindle machine can be accomplished with a horizontal spindle machine when equipped with one of these attachments.

Fig. 28

In die sinking, as well as all kinds of surface milling, the advantage of having the work flat on the table and in plain sight of the operator is readily appreciated. For metal patterns and similar work, these attachments are especially valuable, as a line or template can be followed very closely, thus reducing the hand finishing to a minimum.

It is very essential in designing attachments of this kind, that ample provision be made for solidly clamping the mechanism to the machine, and unless this can be done, their value is greatly restricted. The method of clamping shown in the accompanying illustrations is such that the attachment becomes practically an integral part of the machine. To be practical, the method of clamping must also be simple, for much of the value of an attachment lies in the convenience with which it can be put on and taken off the machine.

In all cases, the spindles of the attachments illustrated can be set to any angle from a vertical to a horizontal position, the angle being indicated by graduations reading to degrees.

Attachments of this kind are usually driven from the machine spindle through bevel gears, but Fig. 28 shows one that is driven by

Fig. 29

Fig. 30

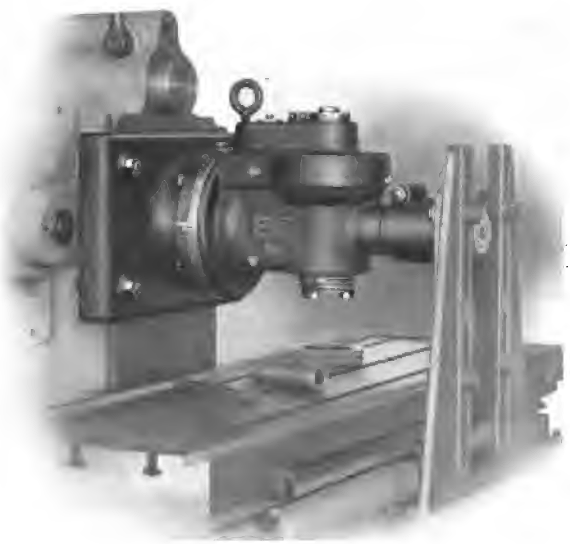


Fig. 31

means of a worm and wheel, and Fig. 31 illustrates one where spur gears are employed in addition to bevel gears.

Vertical Spindle Milling Attachments as built by us are divided into two classes, light and heavy. With one exception, all of our Machines can be fitted with both light and heavy styles.

Fig. 28 shows a light attachment for the smaller sizes of machines, and Fig. 29 a heavy style for the same machines; those shown in Figs. 30 and 31 are respectively light and heavy styles for the larger sizes of machines. The spindle nose of the heavy design attachments is threaded to receive face milling cutters; on those intended for very

Fig. 32

heavy work, such as that shown in Fig. 31, the end of the spindle has a recess for arbors and collets that are clutch driven. The outer end of this last attachment is provided with a bearing that is stiffly supported by the arm braces.

Compound Vertical Spindle Milling Attachment. The compound Vertical Spindle Milling Attachment, shown in Fig. 32 is particularly applicable to a large variety of milling, because it can be set in two planes. (See illustrations.) It is especially advantageous when it is desired to set the spindle at an angle to the table, as in milling angular strips, table ways, etc., for with the spindle in this position, the full length of the table travel is available, and an ordinary end mill, instead of an angular cutter, can be used for milling the angle.

Universal Milling Attachment. Fig. 33 shows the Universal Milling Attachment, and as its name implies, it is fully universal in regard to setting the spindle. In addition to the large amount of work already mentioned in connection with the Vertical and Compound Vertical Attachments, this mechanism can be used for many other operations, because of the fact that the spindle can be set at any angle in both horizontal or vertical planes. It is clamped to the face of the column and the outer end is inserted in the arbor support to give additional stability.

Fig. 33

Horizontal Milling Attachment. We have mentioned the advantages to be derived from the use of vertical spindle milling attachments on horizontal spindle milling machines, and it is reasonable to suppose that to a certain extent, similar advantages are to be gained by the employment of a horizontal milling attachment on vertical spindle milling machines. An attachment of this kind is shown in Fig. 34. It is designed for use upon our No. 1 Vertical Spindle Machine, and with it such work as cutting spiral gears, racks, milling keyseats, etc., can be readily done. It is simple in construction and can be quickly attached to the machine.

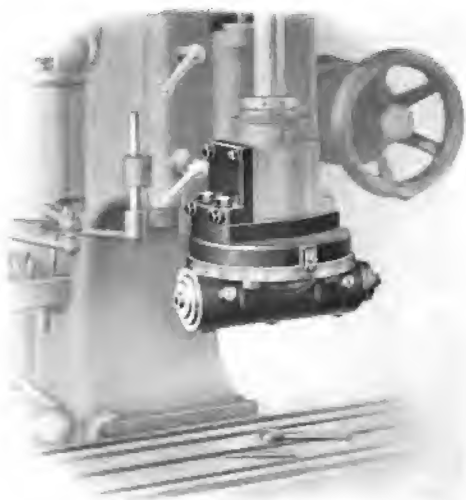


Fig. 34

Circular Milling Attachments. Circular Milling Attachments provide a means of economically doing such work as milling circles,

segments of circles, circular slots, etc., on plain and irregular shaped pieces. With the addition of one of these attachments, a vertical spindle milling machine is fully equipped for all varieties of straight

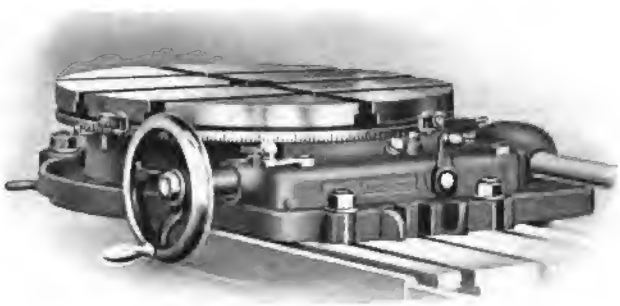


Fig. 35

and circular milling within its capacity. Likewise, one of these attachments used in connection with a vertical spindle attachment offers similar advantages on a horizontal spindle machine. Fig. 35 shows an attachment that can be used on our universal, plain and vertical spindle milling machines. The table is rotated by means of a worm and wheel, and can be fed automatically in either direction by power derived from the table feed screw, or direct from the feed box. It can also be operated by hand when desired. For quick setting, the worm is thrown out of mesh and the table turned to any position. The table remains locked in position when the feed is stopped, but when straight milling or drilling is to be done, an additional clamp, operated by a lever at the side of the attachment, is employed to further insure its stability. The table is heavy and has a wide bearing surface; its circumference is graduated to degrees. The base is provided with an oil rim.

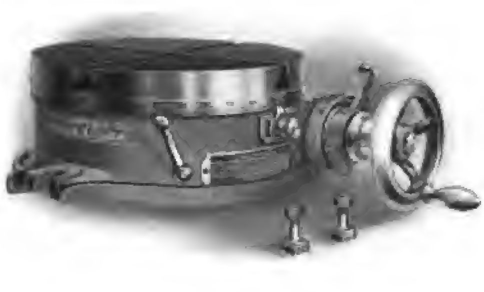


Fig. 36

A Circular Milling and Dividing Attachment is shown in Fig. 36. This attachment

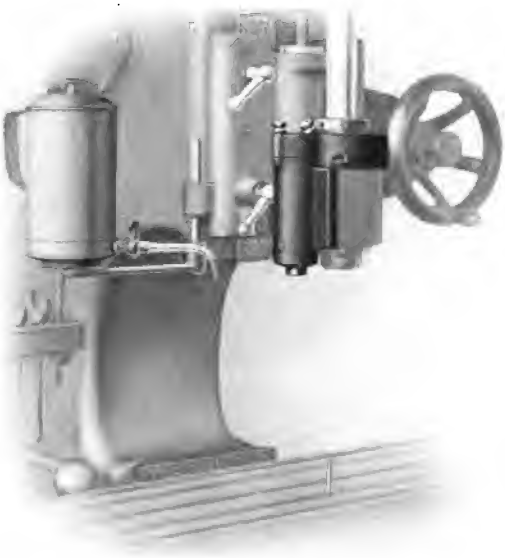


Fig. 37

is adapted for use upon vertical spindle machines, or horizontal spindle machines in connection with the vertical spindle milling and slotting attachments. It has no automatic feed. When used with the vertical spindle milling attachment, the machine is fitted for all varieties of straight, surface and circular milling within its capacity, and with the slotting attachment, for all kinds of slotted work, such as die making, making templates, splining keyways, etc. Its design embodies the same features as the ones just described, and, in addition, the index finger on the front of the attachment is adjustable to allow readings to be taken from any convenient graduation, and an adjustable dial graduated to read to 5 minutes, is fixed to the worm shaft. An index table mounted on the front of the base gives the degrees required for setting the table to produce work with 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 18, 20 and 24 sides. This is particularly valuable for use in connection with the slotting attachment.

High Speed Milling Attachment. Sometimes it is necessary in doing such work as milling keyways and slots, die making, etc., to use a small cutter, which should be run more rapidly than the fastest spindle speed available, otherwise it limits the production and is liable to be broken in feeding. In order to obtain correct speeds for these small mills, high speed milling attachments are employed. Fig. 37 shows one of these attachments for use on a vertical spindle milling machine, and Fig. 38 one designed for

Fig. 38

horizontal spindle machines. The construction in each case can be readily understood, as it consists of nothing other than a pair of gears for increasing the speed and an auxiliary spindle that drives the cutter.

Fig. 39

Slotting Attachment. This attachment, shown in Fig. 39, is largely used in tool making, such as in forming box tools for screw machines, making templates, splining keyways, and work of a similar character. The working parts consist of a tool slide that is driven from the machine spindle by an adjustable crank that allows the stroke to be set for different lengths. The attachment can be set at any angle between 0 and 90°, either side of the centre line, the position being indicated by graduations on the circumference of the head. The tool is held in place by a clamp bolt, and a tool stop that swings over the top of tool shank makes it impossible for the tool to be pushed up.

Spiral Attachment for Cutting Short Leads. In cutting spirals with a spiral head, as the lead becomes shorter and a higher ratio of gearing becomes necessary, the stress upon the gears and mechanism becomes greater. For this reason, it is impractical to cut spirals of very short leads in this way. The spiral attachment shown in Fig. 40 is designed particularly for use when it is desired to cut short leads; those as short as .05 inches being easily obtained without undue stress upon any part of the machine.

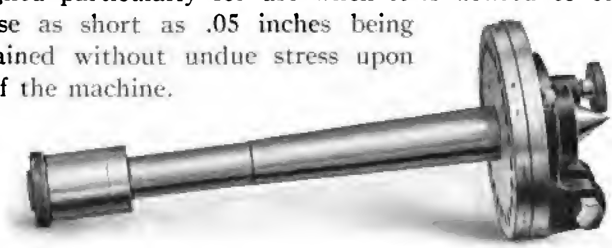


Fig. 40

It consists of a centre which fits into the spindle of the spiral head. The front end is provided with a plate loosely mounted, carrying a driving dog, and an index locking pin which may be securely locked to an index plate fastened to the centre. From the rear, or small end of the centre, a train of gearing necessary to cut the desired lead extends down to the table feed screw. By connecting the table feed

Fig. 41

screw direct with the spiral head centre in this manner leads are obtained that are only one-fortieth of the usual leads cut when the gearing connects with the worm in the spiral head. An explanation of this method of gearing has already been given on page 62. For method of calculating change gears, see pages 58 and 63.

Rack Cutting Attachment. An attachment for cutting teeth in racks is shown in Fig. 41. It can also be used in connection with the spiral head for cutting worms, on Universal Milling Machines, as shown on page 172, and for other miscellaneous operations.

The cutter is mounted on the end of a hardened steel spindle that extends through the attachment case parallel to the table T slots. This spindle is powerfully and smoothly driven from the machine spindle by a train of hardened steel bevel and spur gears.

A vise, the construction of which can be plainly seen in the cut, is furnished as a part of the attachment.

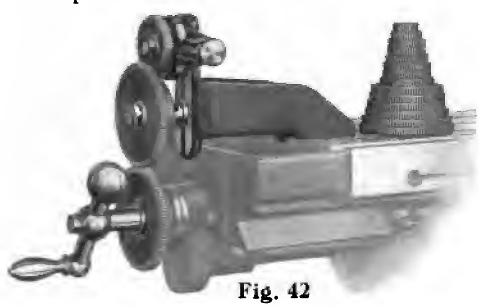


Fig. 42

When cutting racks, some convenient means of indexing to quickly and accurately space the teeth is necessary. Fig. 42 shows an indexing attachment designed for this purpose. It consists of a bracket that is fastened in the table T slot at the left-hand end. The bracket carries a locking disk, together with change gears for gearing to the feed screw. To index any required spacing, change gears are selected that will produce one or more whole turns of the locking disk. For each division the locking pin is withdrawn and the table

advanced by the crank on the feed screw until the pin drops into the slot again, and locks the disk. This method of indexing is therefore much easier than relying upon a dial such as ordinarily used for the purpose.

Fig. 43

Tilting Table. A handy attachment, known as a Tilting Table, is shown in Fig. 43. It is designed primarily for use in connection with index centres when fluting taper reamers, taps, etc. In addition to this work, many other kinds of taper pieces can be accurately reproduced. Its general characteristics, the manner in which it is fastened to the table, and the way that it is elevated, are all clearly shown in the cut.

Cam Cutting Attachment. The Cam Cutting Attachment, shown in Fig. 44, is used for cutting the race in either Face or Peripheral Cams from a flat former. The former is made from a disk about $\frac{1}{2}$ inch thick, on which the required outline is laid out. The disk is machined or filed to the required shape.

The table of the machine remains clamped in one position during cutting, and the necessary rotative and longitudinal movements are contained in the mechanism itself. The rotative movement is obtained by a worm driving a wheel fixed to the spindle of the attachment. The former is secured to the face of the worm wheel, and as the wheel revolves, the former depresses a sliding rack that in turn drives a pinion geared to another rack in the sliding bed of the attachment, thus giving the necessary longitudinal movement. In the cut the former is shown in position on the face of the worm wheel.

The attachment is sometimes driven automatically by means of a round belt leading from a small jack-shaft to a three-step cone pulley fastened on the end of the worm shaft. The pulley is clutched to the worm so that either hand or automatic feed may be used by the simple movement of a lever. Illustrations of the use of this attachment are to be found in chapter IX.

Scales and Verniers for Milling Machines. Scales and verniers are useful on such work as boring jigs, fixtures, or wherever extreme

Fig. 44

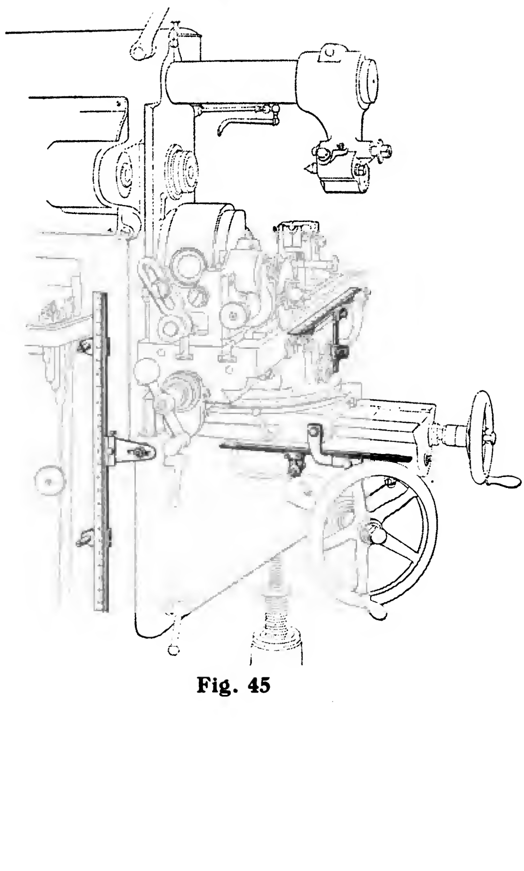


Fig. 45

accuracy is required and it is necessary to make fine adjustments of the table. The scales are graduated to 40ths of an inch, and the verniers read to thousandths of an inch. A machine with all of the table adjustments fitted with scales and verniers is shown in Fig. 45.

Spring Chucks. Fig. 46 shows an unassembled spring chuck. This chuck is convenient for holding wire, small rods, straight shank drills, mills, etc. The collet holder is of steel, ground to fit the standard taper hole of the machine spindle, and has a hole its entire length. The front end is fitted to receive a spring collet, which is held in place by a cap nut that forces it against the taper seat and closes the chuck centrally. A nut is provided for withdrawing the collet holder from the spindle.

In addition to the attachments already mentioned in this chapter, there are many minor fixtures frequently used in milling operations. These are spoken of in connection with general notes on milling in chapter VII.

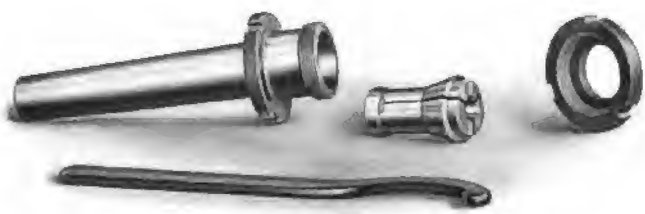
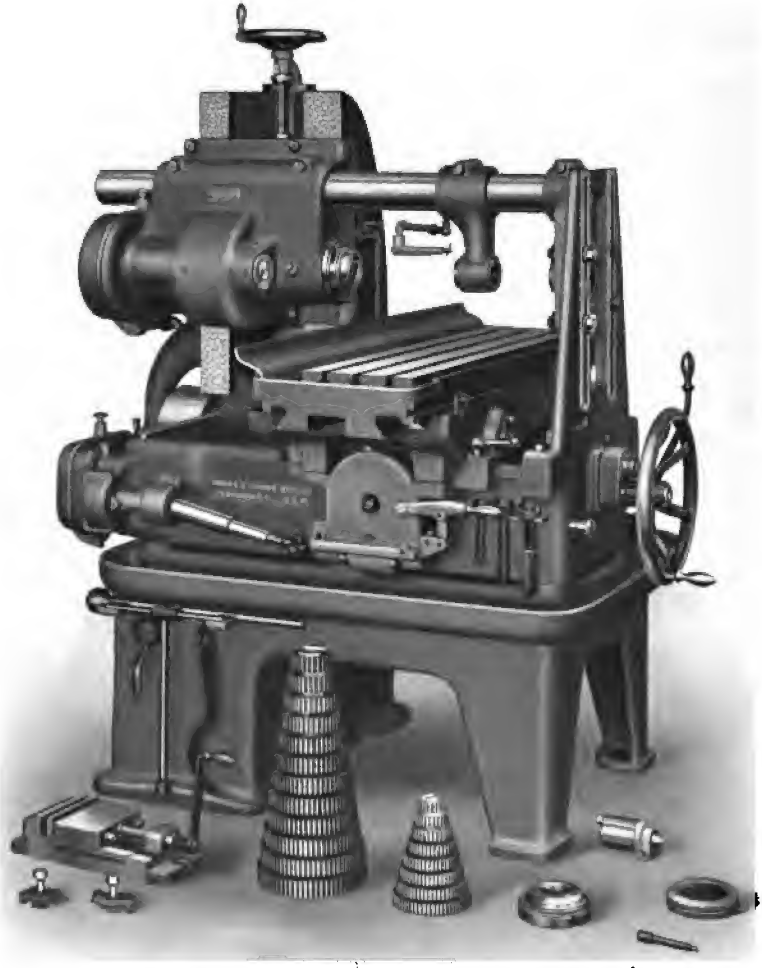


Fig. 46



Manufacturing Milling Machine

CHAPTER VI

Cutters

The development of the manufacture of milling cutters, and a better understanding of their care and use, have resulted in a rapid growth in the number and variety of milling operations, and a corresponding increase in the sizes and varieties of cutters. It is evident, therefore, that the selection, care and use of milling cutters are points of utmost importance in attaining success in the process of milling. The failure to obtain commercial results may often be attributed to the fact that the wrong cutter has been used on a certain job, or even if the right cutter has been chosen, the work has not been done under the most favorable conditions.

Either the operator or the person in charge of the job should be proficient in the selection and care of cutters, and capable of determining the correct speeds and feeds at which to operate them. No theoretical knowledge of the design and manufacture of cutters is necessary to aid in this work, although a general understanding of these points is of material help. While we are able to give in the following pages such information as applies in common to the running of milling cutters, the most valuable experience will come only through actual work at the milling machine.

Carbon and High Speed Steel. Milling cutters are made from either of two varieties of steel, known as Carbon Steel and High Speed Steel. Those made from High Speed Steel can be subjected to more severe service than those made from Carbon Steel, and they are especially desirable where large amounts of metal must be removed rapidly, as in roughing out pieces of work. Cutter manufacturers can usually furnish all styles and sizes in either steel. No fixed rules can be given for their choice. The requirements of each job and experience in the use of cutters must determine which steel is more economical and will give the most satisfactory results.

Plain Milling Cutter. This is a common type of cutter found in every shop, and may be described as a cylinder having teeth on the periphery only and producing a flat surface parallel to its axis. It is manufactured in a large variety of diameters and widths to meet

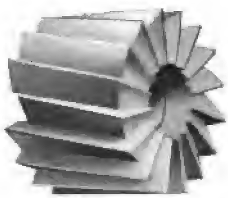
Plain Milling Cutter

Plain Milling Cutter with Spiral Nicked Teeth

Side Milling Cutter

End Mill with Straight Teeth

End Mill with Spiral Teeth



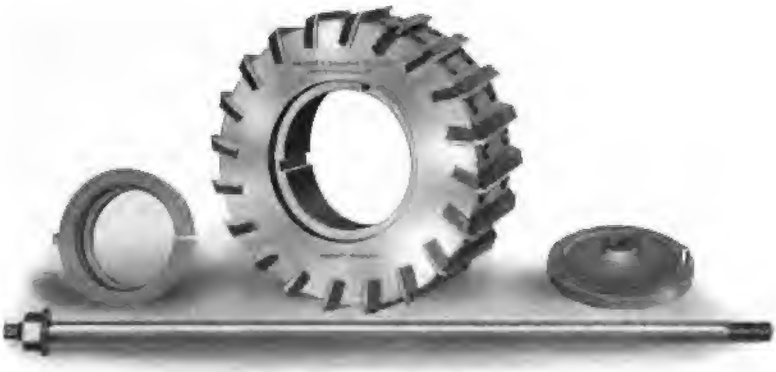
Shell End Mill with Spiral Teeth

Centre Cut End Mill

Two-Lipped Slotting End Mill

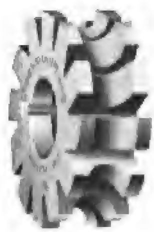
Metal Slitting Saw

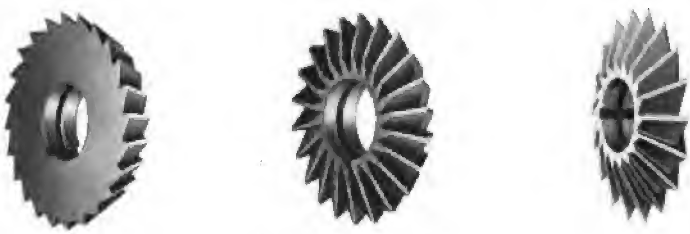
T Slot Cutter



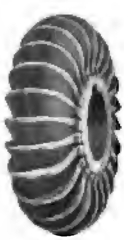
Inserted Tooth Face Milling Cutter with Taper Sleeve and Drawing-In Rod

Convex and Concave Cutters with Teeth that can be sharpened without changing Form

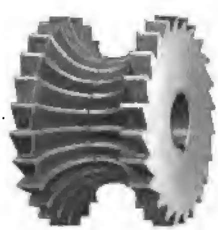




Angular Cutters



Convex and Concave Cutters with Plain Milling Cutter Type of Teeth



Form Cutter. Teeth can be sharpened without changing Contour

different requirements in slab milling, cutting keyways in shafts, etc. Saws for slitting metal and slotting screws are essentially plain milling cutters, although rarely regarded as such on account of their extreme thinness.

Plain milling cutters $\frac{3}{4}''$ or less in width are usually made with straight teeth, while those above that width have teeth of a spiral form. The object of the spiral is to give a shearing cut, reducing the stress upon the teeth, and preventing a distinct shock when each tooth engages the work as is the case with straight teeth. Consequently, a spiral tooth cutter on wide surfaces produces much smoother results

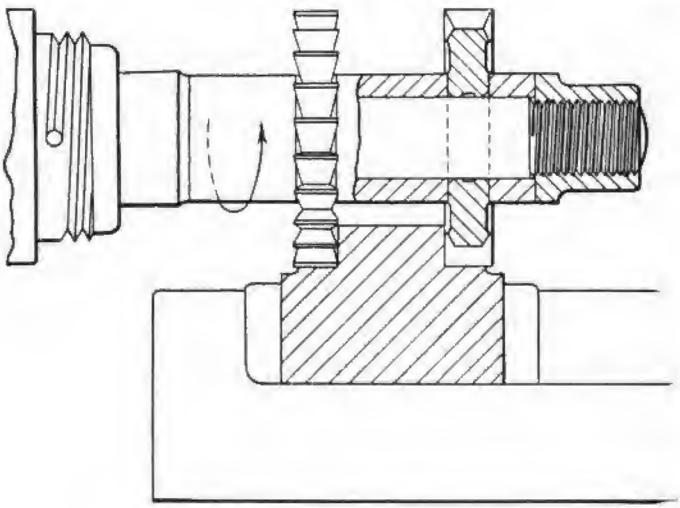


Fig. 47

than a straight tooth cutter. It requires less power to operate, and, in relieving the cutter of strain, the tendency to vibrate or chatter is reduced.

The teeth of cutters, especially those of a wide face, often have notches or nicks cut in them, the nicks following each other alternately. Cutters made in this manner can be run at coarser feeds than those with plain teeth, for the nicks break up the chips, and help to keep the cutters cool.

Side Milling Cutter. This type of cutter is like a plain milling cutter with the addition of teeth on both sides.

Side milling cutters are employed on a large variety of work, being used often in pairs with a space between, as shown in Fig. 47. When so used, they are known as "straddle mills." In work that has to be

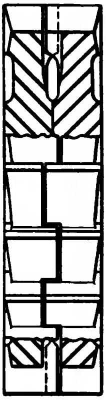


Fig. 48

milled on two parallel sides at once, as milling the heads of bolts, nuts, tongues, etc., straddle mills can be used most advantageously.

These cutters are also made with interlocking side teeth for milling slots to standard width. The teeth interlock, as shown in Fig. 48, and the standard width of the slot is maintained by packing washers between the cutters.

Face Milling Cutter. This cutter may be likened to a disk with teeth on the periphery and on one face. It is fastened at the end of the machine spindle, and the teeth on the flat face come in full contact with the work, while only a small length of the teeth on the periphery act on the piece. There are cutters of this type made which have no teeth on the periphery; an example of one is shown in Fig. 49.

End Mill. This type of cutter, like the face milling cutter, has teeth on the periphery and at the end.

End mills are used for a large variety of light milling operations, such as milling cuts on the periphery of pieces, cutting slots, and facing narrow surfaces. They are made in four distinct styles, the ordinary solid end mill, with either straight or spiral teeth, the end mill with centre cut, the slotting end mill with two lips, and the shell end mill with either straight or spiral teeth.

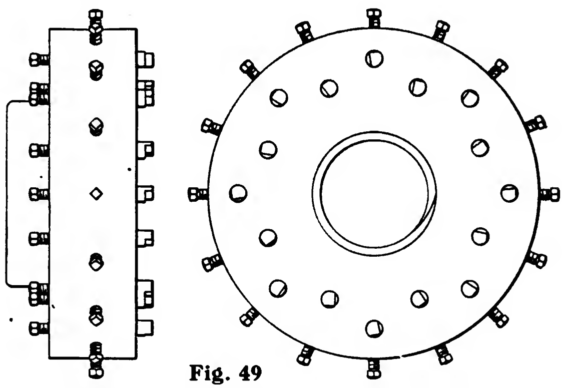


Fig. 49

The ordinary solid end mill has its teeth cut on the same piece of steel that forms its shank; in reality, the space where the teeth are cut is only a continuation of the shank. The shell end mill has a hole through the centre so it can be mounted on the end of an arbor. This type should be used whenever possible, because it is cheaper to replace when worn out or broken than the solid mill. End mills with centre cut differ from the others in that the end teeth are designed to cut at the inner ends, while these teeth in ordinary end mills have no cutting edge at the centre. Centre

cut end mills are used for milling shallow recesses in a surface where there has been no hole previously bored for starting the cut, for milling squares on the ends of round shafts, and other similar work. This form of mill has fewer teeth, and is, therefore, better adapted to taking heavy cuts than the regular solid or shell end mills. Slotting end mills with two lips, or cutting edges, are especially adaptable to fast milling of deep slots from the solid where there has been no hole previously drilled for starting the cut. In fact, these mills embody both the principles of a drill and end mill. A depth of cut equal to one-half the diameter of the mill can usually be taken from solid stock. The best results are obtained by maintaining a high surface speed.

End mills with right-hand teeth usually have a left-hand spiral, and those with left-hand teeth have a right-hand spiral. By having the direction of spiral opposite to the faces of the teeth the thrust of the spiral tends to force the shank of the mill solidly into the spindle, although there is little danger of pulling out the mill when the teeth and spiral are of the same hand.

T Slot Cutter. The T slot cutter has teeth upon its periphery, and alternating teeth on the sides. The teeth are cut in the same piece of steel that forms the shank, as in the case of solid end mills. In making a T slot, an ordinary side milling cutter, or a two-lipped end mill, is first used, and then the wide groove at the bottom is formed with the T slot cutter.

Angular Cutters. Angular Cutters differ from the cutters described above in that the teeth are neither parallel nor perpendicular to the axis of the cutter, but are at some oblique angle. The cutter may have more than one angle.

These cutters can be employed on a variety of work, as cutting the edge of a piece to a required angle and milling teeth of cutters and reamers. Where the nature of the work is such, as in dovetailing a piece, that the cutter cannot be fastened to the arbor with a nut, the cutters are furnished with threaded holes, or made solid on a taper shank.

Form Cutters. Form Cutters constitute an important group, their cutting edge usually being an irregular outline. Two styles of form cutters are made. On one, the teeth are of the same type as those of plain milling cutters, and are sharpened by grinding on the tops. This, of course, changes the contour of the teeth and the outline produced by them, which constitutes an objection to this

style where it is desired to maintain the original form. The other style of cutter has teeth that are relieved so that they may be resharpened repeatedly, or until the teeth are too slender to permit further grinding, without changing the original form so long as the teeth are ground radially on their faces. Illustrations of these two styles are shown on page 91, and Figs. 50 and 51 show the extent to which the latter style can be ground without changing the form of the teeth. Form cutters with teeth relieved so that they may be ground on the faces without changing the contour, should be employed wher-

Fig. 50

Fig. 51

ever the requirements of work demand that the original form of the cutter be maintained, as in manufacturing duplicate irregular pieces.

With this style of cutter, exact duplicate pieces of irregular outline can be produced far more cheaply than by any other method. In fact, no invention has so revolutionized the manufacturing of small parts of machinery and tools.

Concave and convex cutters, cutters for grooving taps, corner rounding cutters, gear cutters, etc., are made with teeth relieved so that they may be sharpened repeatedly without changing the contour.

Concave and convex form cutters are also commonly made with plain milling cutter type of teeth, but it is necessary to have special grinding machines for them, and the concave cutters have to be made interlocking to preserve the size of circle.

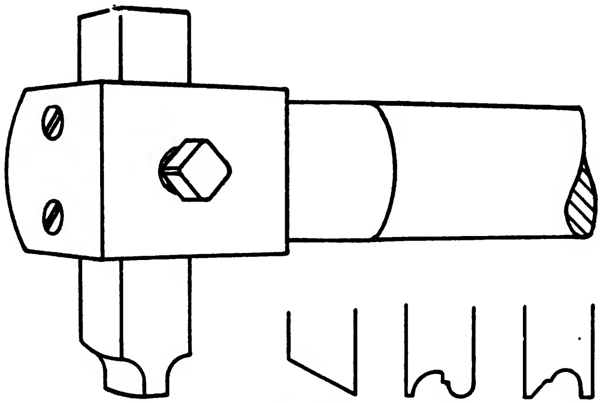
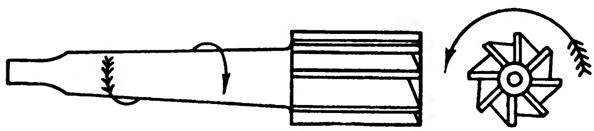
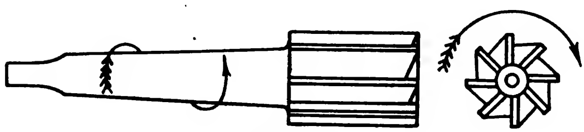


Fig. 52



Right Hand



Left Hand

Fig. 53

Fly Cutter. The most simple form cutter is the fly cutter, shown with its holder in Fig. 52. This cutter is very similar to a planer tool but is held in an arbor and rotated instead of being clamped in a tool head. It can hardly be classed with the cutters previously mentioned, for it is rarely used outside of the tool room or in experimental shops, but there it fills an important place. As it has only one cutting edge, it mills accurately to its own shape, but it does not cut so fast or wear as long as cutters with a number of teeth. It can be formed very exactly to any desired shape at a comparatively small expense, and thus may be used for many operations that otherwise would not bear the cost of special cutters, as, for example, when one or two teeth of special form are wanted in experimental work. The outlines of several possible shapes are shown in connection with the figure.

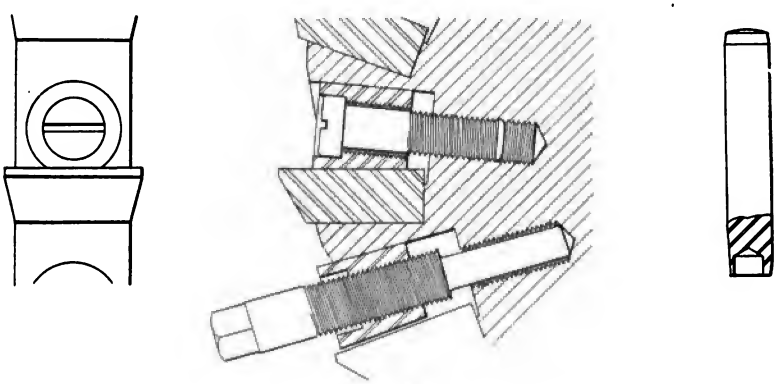


Fig. 54

Right and Left-Hand Cutters. Cutters or end mills with taper shanks and those which have end teeth, may be either right or left-hand, according to the direction in which the cutting edges of the teeth point. Taking an end mill for example, a right-hand mill is one which, held in the hand with the teeth away from you, presents the cutting edges of the teeth when revolved to the right or clock-wise. A left-hand mill is one that, similarly held, presents the cutting edges of its teeth when revolved to the left. Milling cutters having straight holes can be used either right or left-handed as desired.

Inserted Teeth. Plain milling cutters above 8 inches diameter, side milling cutters above 6 inches diameter, and face milling cutters, are usually made with inserted teeth. The body of the cutter is of steel, the teeth being held securely in place by various means. We employ a bushing and screw for this purpose, as shown in Fig. 54.

The introduction of cutters of this style has done more for heavy milling than any other improvement in the cutter line, for with them the heaviest and fastest cuts can be taken, and should any of the teeth become broken, it is not a question of a new cutter, but simply that of replacing the broken teeth. The economy of this is of considerable importance to a shop.

If, for any reason, it becomes necessary to replace the full set of blades, or teeth, the new ones are clamped securely in position, and afterwards sharpened to correct any slight difference in height.

Teeth are released by removing the screw and inserting an extractor that threads into the bushing, and has a long end that reaches to the bottom of the hole in the cutter body. This extractor is shown in position in Fig. 54. As the extractor is turned by means of a wrench, the bushing is forced out and the tooth can then be removed.

Another type of inserted tooth face milling cutter that can be easily made in any shop is shown in Fig. 49. The teeth in this case are simply round pieces of steel inserted in holes made in the cast iron body of the cutter, and held in place by set screws. Sometimes two sets of teeth are put in these cutters. With this arrangement on heavy work that is not wider than the diameter of the inner circle of teeth, and which does not require close limits, the outer circle of teeth can be set to take a roughing cut, and the inner circle to take the finishing cut; thus work can be finished milled at one traverse of the table. Or if an exceptionally heavy roughing cut is to be taken off, the stress can be divided between the two circles of teeth.

Method of Holding Face Milling Cutter. Considerable trouble is often experienced in removing an ordinary face milling cutter from the spindle of a milling machine, and the cutter or the machine is sometimes damaged.

The face milling cutter shown at the top of page 91 and in Fig. 55 overcomes this difficulty. The principle embodied in its construction is that of a split sleeve, with a steep outside taper that screws on the nose of the spindle, and over which the cutter is drawn by a clamping plate and drawing-in bolt. This causes the sleeve to contract and firmly grip the spindle, giving a powerful and efficient drive. The cutter is keyed to the sleeve.

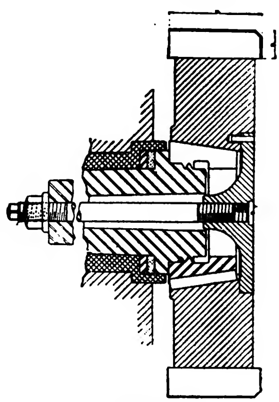


Fig. 55

When it is desired to use one cutter on machines of different sized spindles, special sleeves are needed, the inside diameter varying to fit the spindles, while the outside diameter fits the cutter. This reduces the number of face milling cutters to be kept on hand.

Quick release is obtained by means of the steep taper on the sleeve. When the clamping plate is released, by loosening the drawing-in bolt, the cutter is free. The split sleeve expands and can be easily unscrewed from the spindle.

An additional advantage is found in the increased available working space. There is no long hub, as the cutter is held close to the spindle. The body of each cutter is made of steel, and the blades of high speed steel.

Number of Teeth in Cutters. This subject has been discussed at some length by various writers in books and technical papers. Standard cutters have been found satisfactory for the majority of work. But in roughing out pieces, where the object is to remove much material, and as fast as possible, cutters with fewer teeth than the standard mill will be found better. It has also been found that a short lead spiral on coarse tooth cutters adapts them to a large range of work that is not of the heavier class. In the extensive tests that we have conducted, such cutters show important savings in horse-power required over those with a larger number of teeth, and this, of course, is a good point in their favor.

Angle of Tooth Face. Single point tools such as those used on the lathe and planer are usually given a slight rake; that is, the face of the tool is undercut a few degrees from a radial line. A similar practice is followed in setting the teeth in the body of large inserted tooth cutters so that they have a certain amount of rake. A smoother cut is gained and less power is consumed than would be with radial teeth. For other cutters, however, it will be found that satisfactory results as to finish are gained with cutters whose tooth faces are perfectly radial. Practically all ordinary stock cutters with the above noted exception have radial teeth.

The clearance or angle of the teeth back of the cutting edge is also of considerable importance, and it will be taken up later in connection with sharpening cutters.

Diameter of Cutters. It is well to use cutters as small in diameter as the strength will admit. The reason is shown by Fig. 56. Suppose

the piece I D C J E is to be cut from I J to D E. If the large mill A is used, it will strike the piece first at I when its centre is at K, and will finish its cut when the centre is at M. The line G shows how

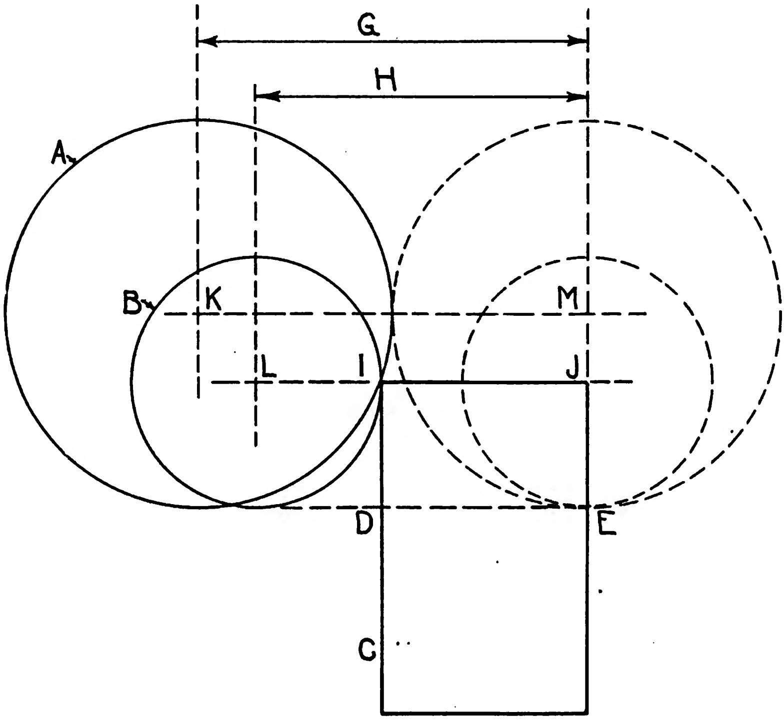


Fig. 56

far the work must travel to cut off the stock I J D E. If the small mill B is used, however, the work travels only the length of the line H.

Small mills are also preferable because they can do more and better work than larger ones, as there is less possibility of their chattering. Furthermore, they require less power and are not as expensive as large mills. The advantage of small mills has been illustrated in our own works, where a difference of ½ an inch in the mills has made a difference of 10% in the cost of the work.

Temper of Cutters. A cutter is not necessarily too soft because it can be scratched with a file. On the other hand, care should be taken that cutters are not too hard or brittle, for trouble will quickly

arise from the teeth breaking. If there is any question as to the temper of a cutter, it is better policy to consult with the cutter manufacturers than to attempt to correct it by drawing the temper, or re-tempering.

Gang Milling. Gang Milling receives its name from the fact that two or more cutters are placed together on an arbor and used at one time. Sometimes plain milling cutters are so combined in order to cover a wider space than the longest stock cutter. Again, form cutters are used either with or without plain or side milling cutters. The use of form cutters and plain milling cutters together should be avoided whenever possible, on account of the difficulty of maintaining relative diameters in sharpening the gang.

The value of gang milling is found in the fact that it reduces the cost of production and insures accurate duplication of parts, in that several operations can be performed simultaneously, and with one setting.

It should be kept in mind that in this kind of milling, cutters of the largest diameter, or those that take the heaviest cuts, should, if possible, be used nearest the nose of the spindle, thereby reducing the strain on the arbor. If several of the cutters are plain milling cutters, it is well to use both right-hand and left-hand spirals in order to equalize the end thrust of the arbor. When, in gang milling, the cutters vary considerably in diameter, the inequality of the periphery speeds may be overcome by having the cutters of large diameter made of high speed steel, and those of small diameter made of the ordinary carbon steel.

Speeds and Feeds. Speeds and feeds are of extreme importance when considered in connection with the life and efficiency of a cutter and volume of output. Little can be said, however, in the matter of general rules to follow in determining correct speeds and feeds, owing to the different conditions that exist in different shops, and, in fact, in the same shop, where one set of rules will not always hold on like jobs. The amount of power and rigidity in different machines, kind of material, width and depth of cut, quality of finish required, and many other factors, all enter into the question, and prevent the establishing of any definite rules. Sometimes the speed must be reduced, yet the feed not changed, and vice versa; again both speed and feed must be reduced or increased, as the case may be. Often the rate of feed depends almost wholly upon the degree of accuracy and quality of finish required. In general, work of a delicate character, requiring

an accurate finish, demands light cuts and fine feeds, and work of a heavy character, where the principal object is to remove metal rapidly, requires deep cuts and coarse feeds. On work that permits of heavy roughing cuts, the finishing cuts should usually be light. The feed, inasmuch as it governs the output of work, is of greater importance than the speed of a cutter, and it is generally a safe rule to follow, that the speed should be as fast as the cutter will stand, and the feed as coarse as is consistent with good work. Much must be left to the judgment of the operator as to the correct speed and feed to use for the work in hand, and many cases will require repeated experiments before the best results are obtained. When any difficulty is encountered in obtaining the right combination of speed and feed, it is well to seek the advice of the foreman in charge of the job, or that of a widely experienced milling machine operator.

The following surface speeds will serve to give an idea, or basis, to work from. They may be varied slightly to suit the requirements of the work in hand. Using carbon steel cutters: For brass, 80 feet to 100 feet per minute; for cast iron, 40 to 60 feet per minute; for machinery steel, 30 feet to 40 feet per minute; and for annealed tool steel, 20 to 30 feet per minute, have been found satisfactory. With high speed steel cutters for the same materials, the following speeds are advocated: For brass, 150 feet to 200 feet per minute; for cast iron, 80 feet to 100 feet per minute; for machinery steel, 80 feet to 100 feet per minute; and for annealed tool steel, 60 feet to 80 feet per minute.

Useful tables for determining the number of revolutions per minute to obtain the more common surface speeds of cutters of different diameters, will be found on pages 325 and 326.

Sharpening Cutters. The importance of keeping all kinds of milling cutters well sharpened must not be overlooked. It might be supposed upon first thought that better economy in cutter wear would be gained by regrinding no oftener than positively necessary. This is not the case, however, as experience has shown that a dull cutter wears more rapidly than a sharp one, and consequently one that is kept in good condition by frequent regrinding will invariably outlast one that is not so cared for. Besides, a dull cutter not only consumes more power, but cannot be operated as rapidly or take as heavy cuts as a sharp one, and the quality of the work is never so good. Too frequently in shops today, the efficiency of milling machines is impaired by the use of dull cutters, for no other reason than carelessness

and negligence on the part of the operator. Milling is never a complete success where such conditions exist, and with the improved grinding machines and convenient means of removing and replacing cutters, there is no reason for limiting the capabilities of a machine by using dull cutters. Grinding a cutter takes only a short time, and the good results that are obtained, together with the economy assured, more than compensate for the time expended in grinding. Whenever possible, it is a good plan to have two sets of cutters, so that one set can be reground while the other is in use; the milling machine then need only be stopped long enough to change the cutters.

Plain milling cutters, side milling cutters, end mills, etc., are sharpened upon the tops of the teeth, while form cutters of all kinds are sharpened upon the faces of the teeth. Modern cutter grinding machines are necessary where many cutters are employed, and are advantageous, even where there are only a few cutters used, for it is nearly impossible to properly resharpen cutters, except with a machine especially designed for that purpose. We illustrate at the back of the book the cutter grinding machines we build that are very suitable for use in connection with milling machines.

It is impossible to treat in detail the many points about resharpening cutters without going to great length, but we issue a book and booklet* devoted exclusively to the subject, one of which is furnished with each of the machines mentioned above.

Clearance on Cutters. The clearance or relief of milling cutters is the amount of material removed from the top of the teeth back of the cutting edge to permit the teeth to clear the stock and not scrape over it after the cutting edge has done its work. On form cutters, the clearance does not have to be considered in resharpening. This is because the teeth are so formed that when ground on the faces, the clearance remains the same.

The angle of clearance depends upon the diameter of the cutters, and must be greater for small cutters than for larger ones. The clearance on the teeth of plain milling cutters should be 4° for cutters over 3 inches in diameter, and 6° for those under 3 inches diameter. The clearance of the end teeth of end mills should be about 2°, and it is well to have the teeth a little hollowing, making them .001 or .002 inch lower near the centre than at the outside, so that the inner

* "No. 13 Universal and Tool Grinding Machine — How to Use It — What It Will Do," and "Care and Use of the No. 2 Cutter Grinding Machine and No. 3 Universal Cutter and Reamer Grinding Machine."

ends of the teeth will not drag on the work. This can be done by setting the swivel on the cutter grinder slightly away from 90°.

Vibration of Cutters. If the clearance of a cutter is too great, vibrations are likely to occur in operation, and this should be corrected by regrinding the teeth. "Chattering" is a serious drawback to successful milling, as it impairs the quality of the work, limits the capacity and injures a machine, and reduces the life and efficiency of a cutter. While it is impossible in many cases to eliminate it, every precaution should be taken to reduce it to a minimum.

CHAPTER VII

General Notes on Milling, together with Typical Milling Operations

Milling, as we have already explained, is a process that cannot be governed by any fixed set of rules, but there are a few general instructions which, if carefully followed, will enable the machine to be more efficiently operated and largely influence the success that is attained. These we have collected in this chapter, and, in addition, show illustrations of a number of common milling operations to give an idea of how various and widely different jobs can be set up.

GENERAL NOTES ON MILLING

Pickling Castings and Forgings. Due to the rapid cooling or chilling of the outside of castings and forgings, a tough, hard skin, or scale, forms that is very destructive to the cutting edges of the teeth of milling cutters. There is also considerable of the moulding sand left on castings, and this is likewise harmful to the cutting edges. The sand can be removed and scale softened to some degree by the process of pickling, and it is essential that this be done preparatory to milling. Castings are usually pickled in the foundry, but it is well to make sure that this has been done before attempting to mill them. It is also an advantage in some cases to have castings rattled after being pickled. Where they are small, and are to be finished rapidly, they should be annealed.

For pickling castings, a solution of oil of vitriol, or sulphuric acid, reduced with water to a specific gravity of 25° (Beaume hydrometer) is recommended. The castings should be stacked on a bench over a vat containing the solution, and the solution poured over them.

Castings should never be immersed in the pickling bath if they are to be painted, because the iron is more or less porous, and the acid that is absorbed in pickling will work out after the pieces are finished, causing the paint to flake off. Furthermore, the pickle works better when it is poured over the castings and then allowed to dry off before another application of the solution.

The time required for the process is usually about a day, and the solution should be poured over the castings from four to five times.

Forgings may be pickled by immersing in a solution of sulphuric acid and water of 30° specific gravity (Beaume hydrometer) for a period of from 3 to 12 hours, according to hardness of scale.

When either castings or forgings are pickled, they should be thoroughly washed off with hot water, as this will wash out sand and remove the acid better than cold water. The water may be conveniently heated for this purpose by injecting steam into the cold water pipe.

Cutter Close to End of Spindle. In all milling operations, especially the heavier ones, care should be taken to have milling cutters as near the nose of the spindle as practicable. This will reduce to a minimum any possible vibration and spring of the arbor. It also brings the table close to the face of the column and ensures additional rigidity. Other valuable points about cutters have been taken up in Chapter VI, and it may be well to review these previous to starting to operate a machine.

Fastening Cutter on Arbor. See that the ends of the collars and washers are clean, for particles of dirt or chips between them will cause the arbor to be sprung when the nut is tightened. Small cutters can be held securely by the mere clamping effect of the collars on each side when the nut is tightened, but medium and large cutters should always be keyed to the arbor to prevent slipping.

Manner of Driving and Supporting Arbors. Milling machine arbors are driven in several different ways, some of which are shown in Fig. 57. In A, the arbor has a tenon at the small end of the taper that fits a slot at the end of the taper hole in spindle, thus giving a positive drive. The arbors at B and C are driven by the flat clutch shoulder at the large end of the taper. The clutch shoulder fits into a recess in the spindle nose and a cap nut over the end holds the clutch in place.

All milling machines are equipped with some support for the outer end of the cutter arbor. The adjustable centre shown at A is one form that is used for lighter classes, or work where an arbor with a flat tenon is employed. The centre serves to support the outer end of the arbor and helps to keep the flat tenon in place in the slot in the spindle. Another form of support is shown at B. This support is a bronze bushing mounted in the arm that extends down from the overhanging arm, and is used where an arbor with clutch drive is employed. An

example of the use of arm braces that extend from the knee to the overhanging arm and carry the bronze bushing for the outer end of the arbor is shown at C. These braces firmly tie the knee and overhanging arm together, and give a stiff support for the arbor. They should be used whenever the character of the work is heavy. This illustration also shows the use of an arbor support for stiffening the arbor between the cutters. This support should be used to bring a bearing either between or as near to the cutters as possible.

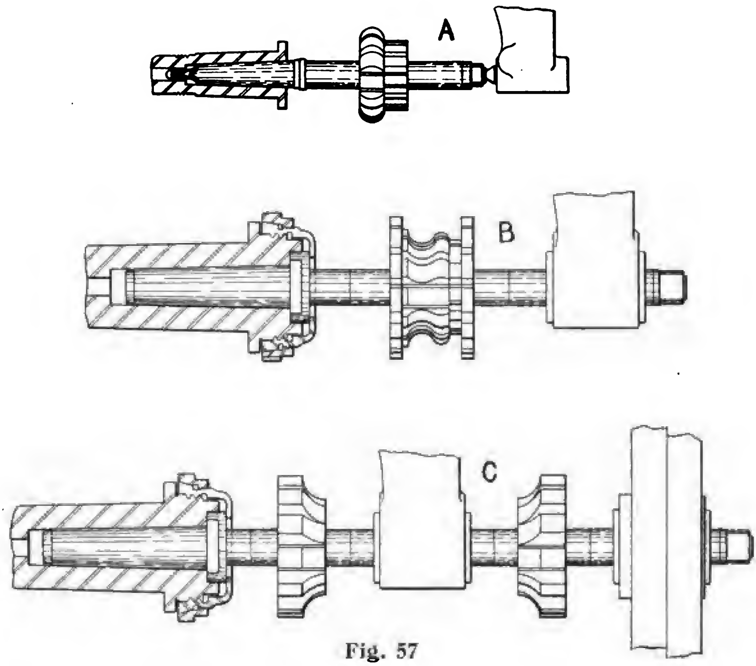
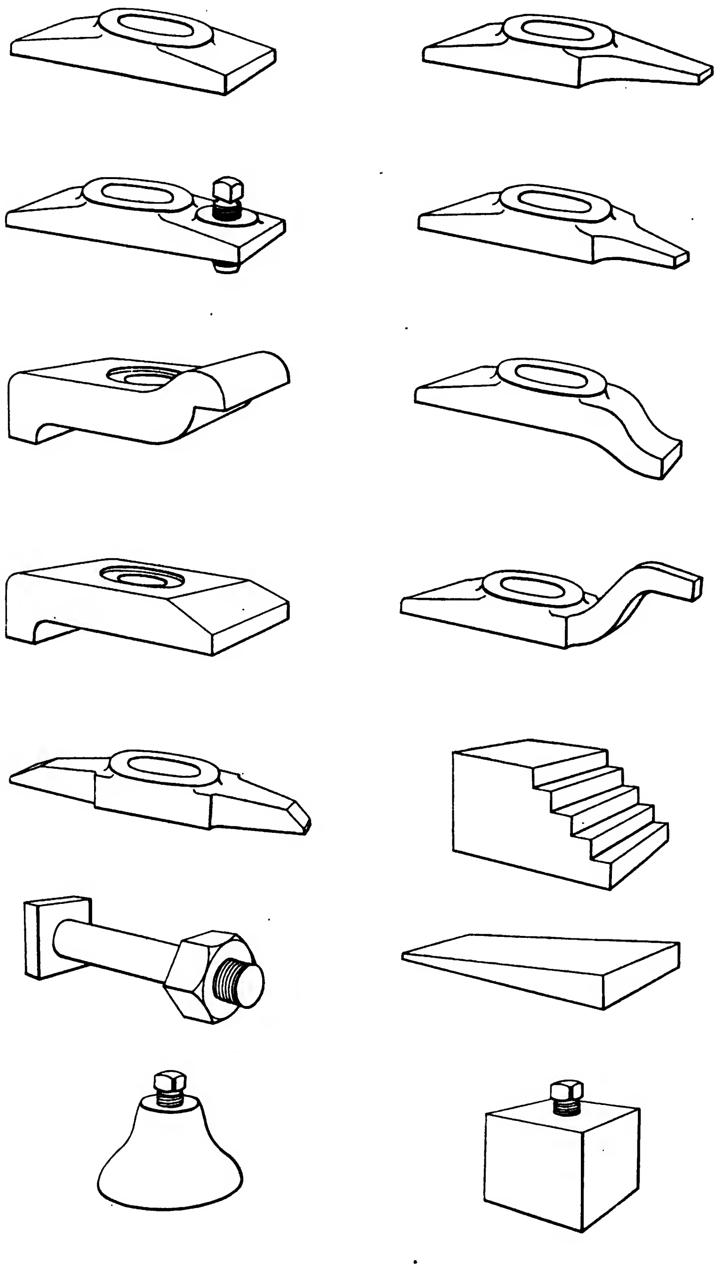


Fig. 57

Before tightening or loosening the arbor nut, when putting on or removing cutters, be sure the arbor support is in position, so a bearing is provided near the nut, otherwise the arbor is liable to spring.

Clamping Work. An operator should pay particular attention to clamping work on a milling machine, for the success of milling is more dependent on this than one would realize at first thought. It is an easy matter to place clamps on some work in such positions that the piece is sprung, consequently when the clamps are loosened and the piece resumes its natural shape, the milled surface is found inaccurate. Again, faulty clamping results in work becoming loosened during operation, and not only impairs the accuracy of the piece, but many



times damages the cutters and machine. It is very essential, therefore, that work be clamped solidly, but in such a manner that it is not sprung.

An assortment of clamps or straps, together with jacks, a shim, step block and clamping bolt, are shown on the opposite page. These accessories form an important part of the equipment of a milling machine, and are needed where a variety of work is done. Several sets of each style of strap, and different sizes of step blocks and clamping bolts should always be at hand for use on work of varied shapes.

Whenever clamping a piece to the table, the straps should be placed squarely across, so as to have a full bearing at each end and, if possible, at points where the work is solid beneath the strap to the table. If it is necessary to place a strap over an overhanging part, such as on the piece of work shown on the next page, some support should be put between the overhanging part and the table, otherwise this part is liable to be sprung or broken off.

Another point in connection with clamping such work is the position of the clamping bolt. It should always be placed as near the work as the slot in the strap or other conditions will permit, for in this position it will exert the greatest leverage on the work and will not require setting up so tightly.

When milling work held in a jig or fixture, it is advisable to have the thrust of the cutter taken against the solid support, not against the removable member, for in this case there is more tendency toward vibrations that might loosen the clamping nuts.

When duplicate pieces are milled, using a fixture, care should be taken to clean the bearing points each time before putting

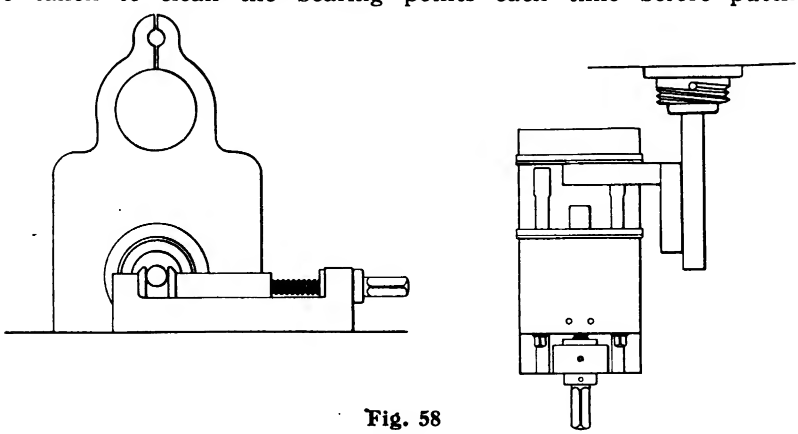
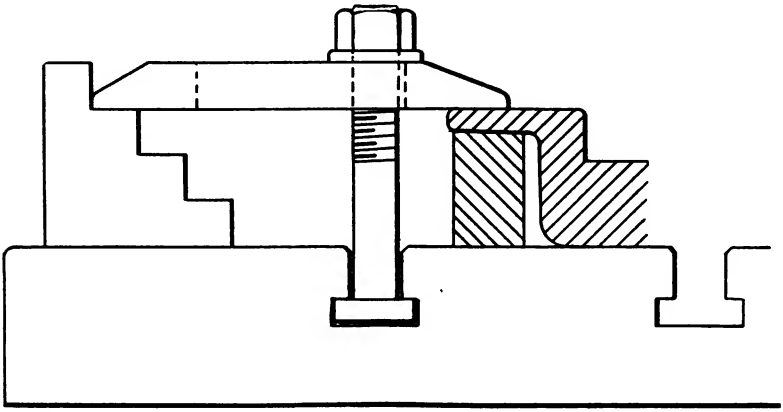
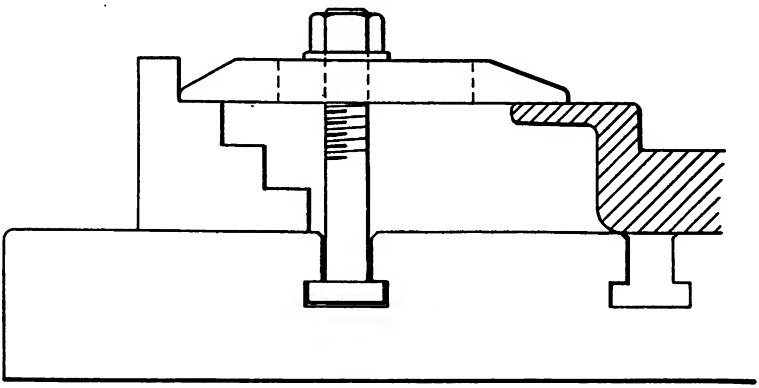


Fig. 58



Right



Wrong

a new piece of work in place. A narrow, stiff hair-bristle brush is good for this purpose when milling cast iron, but one with wire bristles is better for cleaning out steel or wrought iron chips. It is well to clamp a piece lightly, then tamp it down at all bearing points with a hammer; after which it can be solidly fastened.

Aside from these few general instructions on placing and clamping work, little can be said, because the shape of a piece of work alone determines how it may be best fastened. But a study of the methods of clamping shown in the examples of work in this and succeeding chapters will be of great value to the reader.

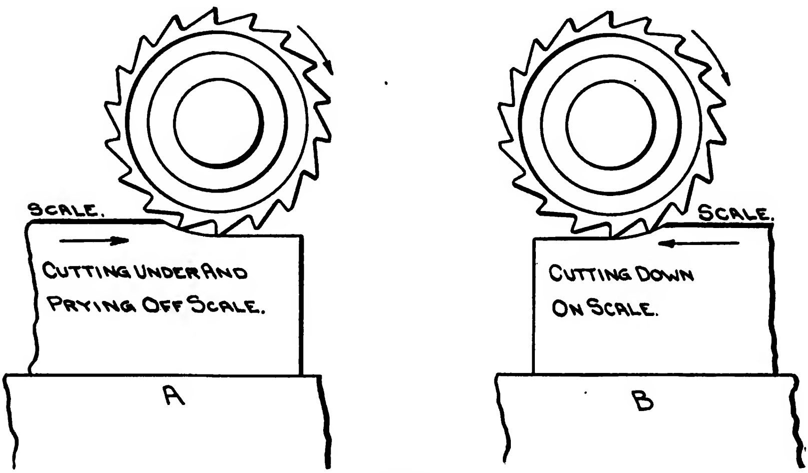


Fig. 59

Setting Vise. Light work is usually held in a vise, as it is more convenient than any other method of fastening it to the table. To set a vise with plain base so that its jaws are parallel to the spindle, place an arbor in the spindle and then bring the vise jaws up to the arbor. (See Fig. 58.) It can be set at right angles with the spindle by a square placed against the arbor and the jaws. The front of the table of the machine can also be used in setting the vise.

Swivel vises can be set by aid of the graduations on their base.

Direction to Move Work Under Cutter. Whenever possible, it is advantageous to feed the work in the opposite direction from that in which the cutter runs. (See A, Fig. 59.) Then the cutter cannot draw the work in as it is liable to do when the table moves in the direction indicated at B. Moreover, when the piece moves as shown at A, the

cutter teeth are first brought into contact with the softer metal, and as the scale on the surface is reached, it is pried or broken off.

On the other hand, in milling deep slots, or in cutting off stock with a thin cutter, or saw, it is sometimes better to move the work with the cutter, as the cutter is then less likely to crowd side-wise and make a crooked slot.

When the work is moving with the cutter, the table gib screws must be set up rather hard, for the teeth of the cutter tend to draw the work in, and if there is any lost motion in the table, the teeth may catch and injure the cutter or work. A counter-weight to hold back the table is excellent in such milling.

With vertical spindle milling machines, when a cutter is working on a flat surface, it does not matter which way the table is fed, but if the cutter is milling a side of a casting, as well as a flat surface, the table should be fed in the opposite direction to that in which the cutter revolves, for the reasons already mentioned.

Limits in Milling to Size. The limit for error in size to which work should be milled depends entirely upon the character of the job. With some work, a limit of one-hundredth of an inch is plenty good enough, while many other pieces must be finished to within one-thousandth of an inch of being exactly parallel or straight, as the case may be.

In milling to a given thickness or size, the most accurate results are ordinarily obtained by straddle mills or side milling cutters; for when only one side is milled at a time, and the piece has to be changed from one side to the other, it is hardly practicable to work to a smaller limit than two-thousandths of an inch. Side milling frequently requires more attention to keep the work smooth than ordinary surface milling.

Very accurate milling may be done and excellent surfaces obtained by small end mills running at high speeds.

In all cases where roughing and finishing cuts are to be taken on work, and precision is required, it is best to first remove most of the stock with a coarse feed, leaving enough for a light finishing cut. At a second operation, finish at a higher speed with a feed that will give the required surface.

Some light work will spring when the scale and a thickness of the metal are removed by the roughing cut. It is, therefore, advisable to loosen the holding clamps and permit the piece to assume a natural form before taking the finishing cut; otherwise, whatever inaccuracy

that might result from the foregoing cause would be present in the finished work.

Remove Backlash or Lost Motion from Feed Screws. Backlash or lost motion is apt to be present in the feed screws and nuts of any machine, especially in those that have been in use some time. To obviate errors in making fine adjustments, the operator should be very careful to eliminate all backlash before setting to the graduations on the feed screw dials. This may be done by turning the hand-wheel a quarter or half turn in the opposite direction to that in which the adjustment is to be made, and then bringing the wheel back to the point from which adjustment is to be made.

Use of Oil or Other Lubricant. Lubricant is used in milling to obtain smoother work, to keep the cutters cool so that the teeth will retain their cutting edges longer, and, where the nature of the work requires, to wash the chips from the work or from the teeth of the cutters. Oil is generally used in milling steel, wrought iron, malleable iron or tough bronze, where a smooth finish is desired. A soda water mixture can also be used to good advantage on these materials.

For very light cuts, oil should be applied to the cutter with a brush; for heavier cuts, it should be allowed to drip freely upon the cutter from a can, and on the heaviest cuts, a large supply of lubricant should be supplied by means of a pump, which can be affixed to the machine.

A good quality of lard oil is generally used, but any animal or fish oils may be employed. An excellent soda water lubricant that is less expensive and cleaner to use than oil, can be made by mixing together and boiling for one-half hour, $\frac{1}{4}$ lb. sal soda, $\frac{1}{2}$ pint lard oil, $\frac{1}{2}$ pint soft soap and water enough to make ten quarts.

Cutting Cast Iron. In cutting cast iron, lubricant is seldom used, as cutters do not usually heat very much, and the chips are so fine that the use of a lubricant results in a sticky mass that clogs the teeth of the cutter, and is difficult to clean from the work and machine.

Compressed air can be used to some advantage on cast iron, and will serve to keep the cutters cool and free from chips. In using compressed air care should be exercised not to have too much pressure, as it will scatter the dust and chips, which will fill bearings and cause trouble.

Collars and Washers for Arbors. Collars sent with milling arbors are not always the right thickness to bring cutters into the desired

position. In these cases, washers should be employed. The following thicknesses are convenient: .001″, .002″, .004″, .008″, .016″, and .032″, as these give all steps from .001″ to .032″.

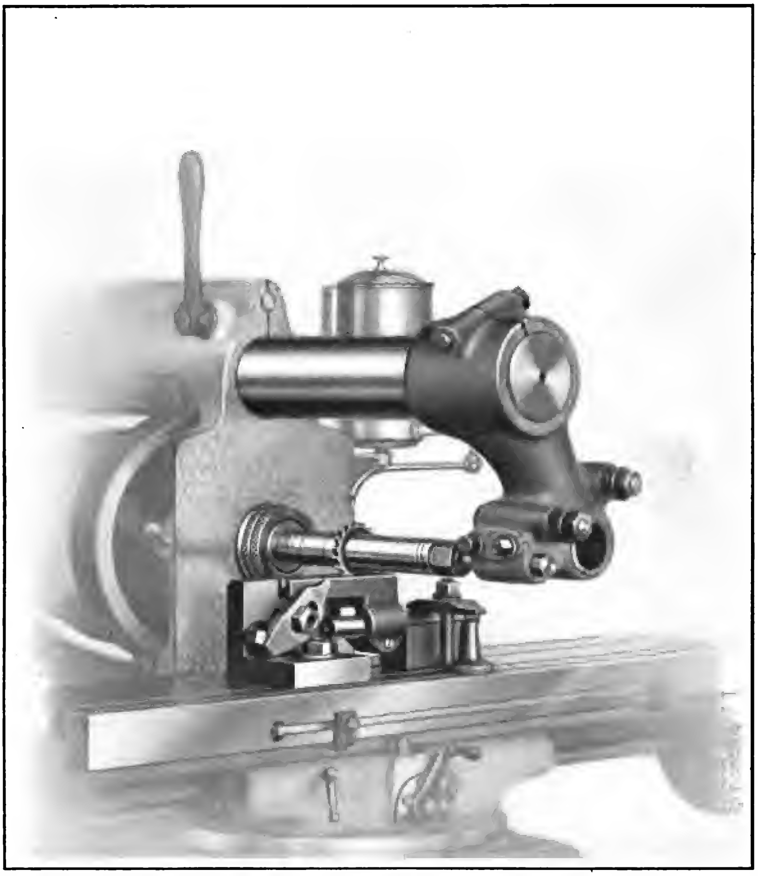
The collars should be of uniform thickness, otherwise they are likely to spring an arbor when they are clamped up.

Lead or Brass Hammer, and Brass Bar. Lead or brass hammers are useful to drive arbors or collets into the spindle, and seat work in a jig or vise. A steel hammer should not be used for these purposes, as it will mar pieces. Short lengths of gas piping with a cap on the protruding end make good handles for lead hammers.

A bar of brass or copper, $\frac{3}{4}$ inch in diameter and five or six inches long, will also be found useful to place against end mills, or the end of small collets after the mills are in place. In this way the driving is often more conveniently done, and any hammer may be used.

TYPICAL MILLING OPERATIONS

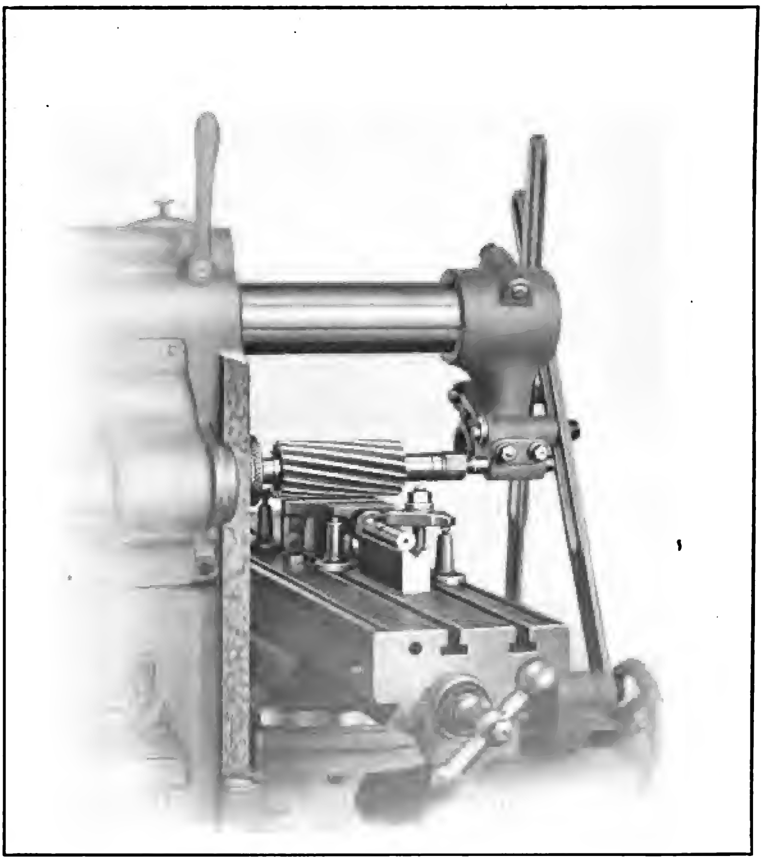
In the illustrations of milling operations given upon the following pages, it should be understood that we have not attempted in every case to show how a job should be rigged up for commercial manufacturing, as special fixtures designed solely for certain operations are then employed. Our object is simply to show the novice how any number of jobs he is likely to meet with daily can be best set up. If it is a question of performing the same operation continuously, special fixtures, by use of which the work can be more conveniently and quickly handled, can be designed.



Milling a Groove in a Machine Part

In the illustration above, the work is of cast iron, in which a groove $\frac{1}{4}$ inch wide is to be milled parallel with the hole. The piece is held on an arbor mounted in a V block and clamped to the surface of the table. Its overhanging end rests on a set screw tapped into the base of a knee bolted to the table, and a bolt and strap clamp the end firmly to the side of the knee.

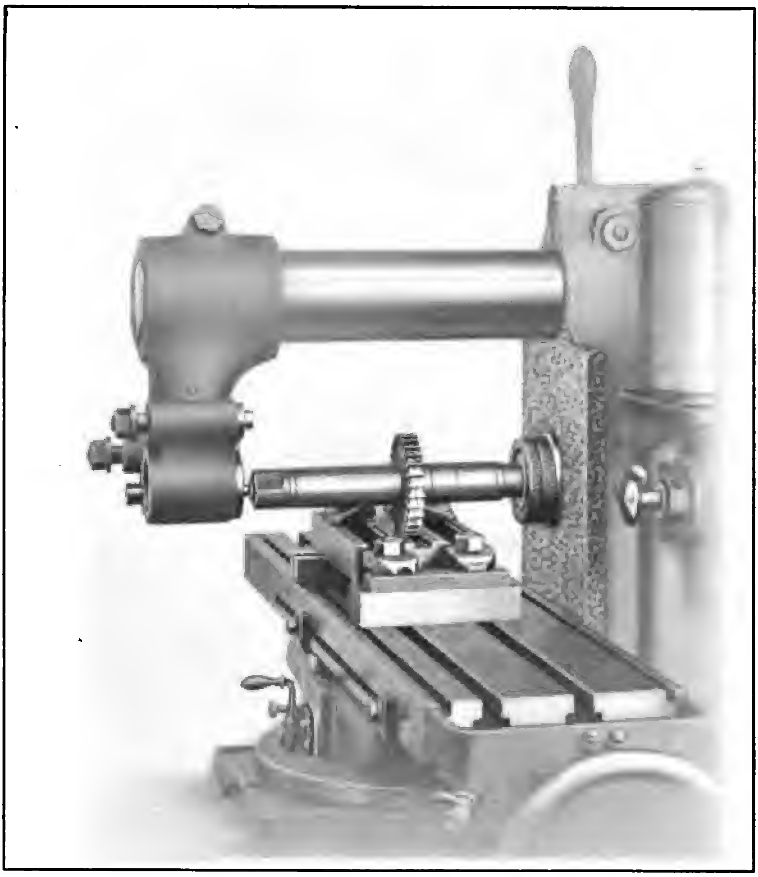
A plain milling cutter $\frac{1}{4}$ inch face, 2 inches diameter, is used, and the table is fed longitudinally.



Surfacing Top of a Bracket

This is a simple and common milling operation. The cast iron bracket is supported on an arbor that rests on V blocks at each end. Bolts and straps hold the arbor and V blocks in place, and the projecting portions of the bracket are supported by small jack screws. As the full width of surface is milled at one cut, the arm braces are used to support the arbor. Also, the cutter is placed as near the nose of the spindle as the work allows.

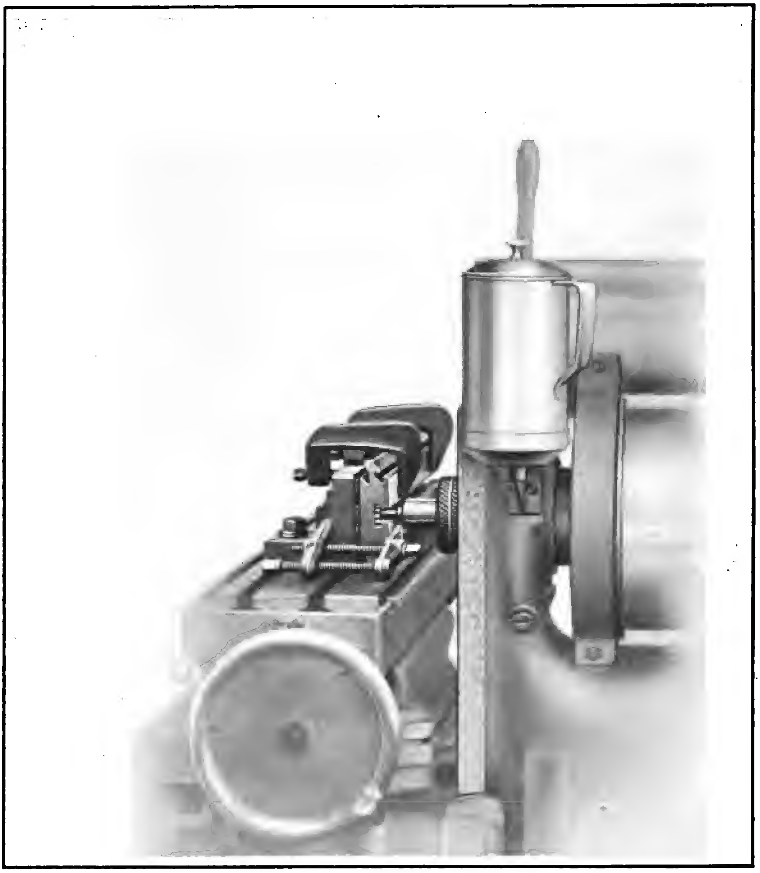
Because of width of cut, a plain milling cutter with spiral teeth, 6 inch face and $2\frac{3}{4}$ inch diameter, is used.



Cutting Slot in Vise Casting

The operation shown on this page is that of milling a slot on the bottom of the base casting of a milling machine vise, such as that shown in Fig. 18. The casting is clamped directly to the table and the farther end is supported on parallels.

An interlocking side milling cutter, $\frac{3}{4}''$ wide, is used, and the table is fed longitudinally. The value of the interlocking cutter is apparent here, for it is essential that the width of slot milled be maintained after the cutters have been ground. This is accomplished by packing thin washers between the two parts of the cutter.

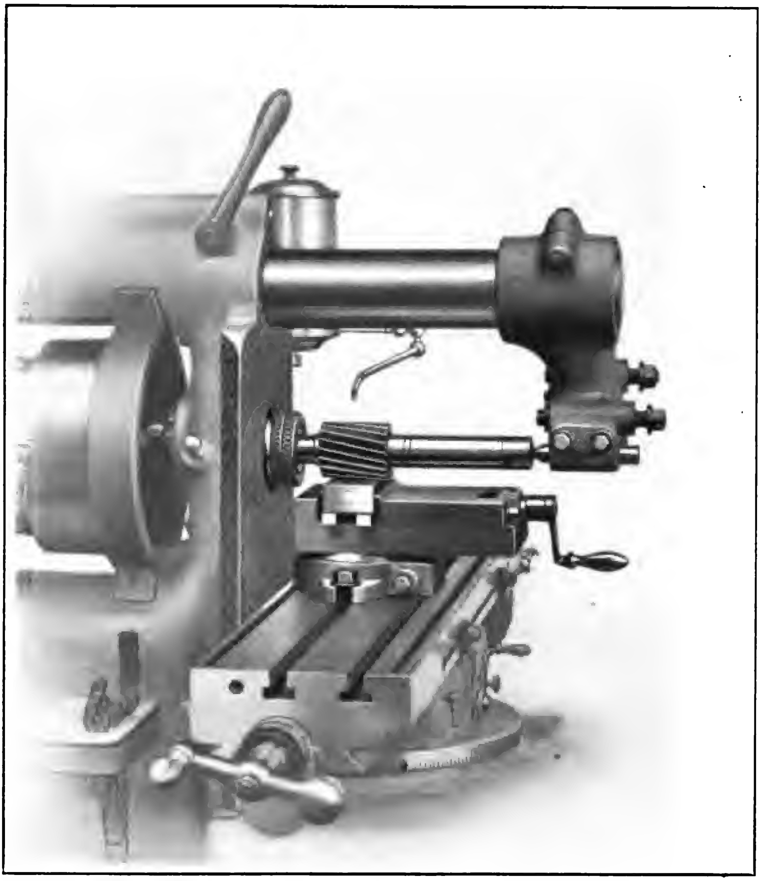


Milling T Slot in a Table

Milling a T slot consists, as we have already explained in Chapter VI, of two separate operations. A straight slot is first milled to the full depth with a plain milling cutter, which is $\frac{1}{2}''$ wide in this case. The work is then turned on edge and clamped to knees so that it is square with the spindle. It is leveled by means of a surface gauge or height gauge, measuring from the straight slot to the top of the table.

A standard $\frac{1}{2}''$ T slot cutter is used, and the table is fed longitudinally in the path of the straight slot.

This job can be done to good advantage on a vertical spindle machine, or with a vertical spindle attachment, using a two-lipped end mill and T slot cutter.

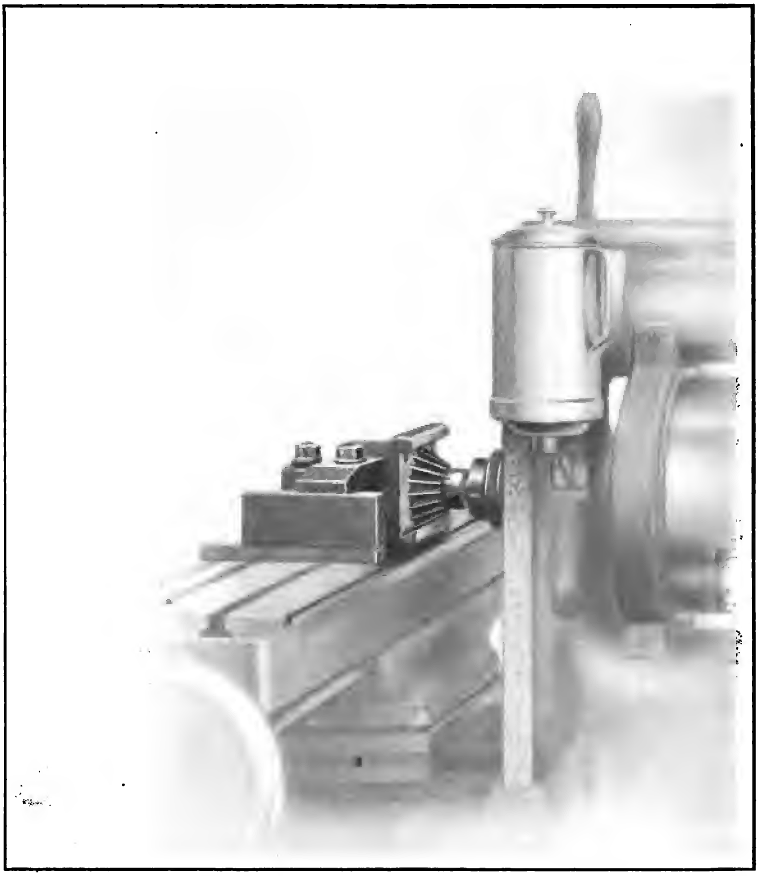


Milling Steel Block for Parallel Sides

This operation is, apparently, simple enough, but care must be exercised if accuracy is required. The piece is supported on parallels and clamped in a vise. In fastening it one must be careful to be sure that there are no particles of dirt or chips between the parallels and bottom of piece, and that it is tamped down so that it seats properly when the vise is firmly clamped.

A plain milling cutter with spiral teeth is used, as this is best where a finished surface is desired. A cutter with nicked teeth would be better if considerable stock were to be taken off.

The table is fed longitudinally, and it should be noted that lubricant is used upon the cutters.

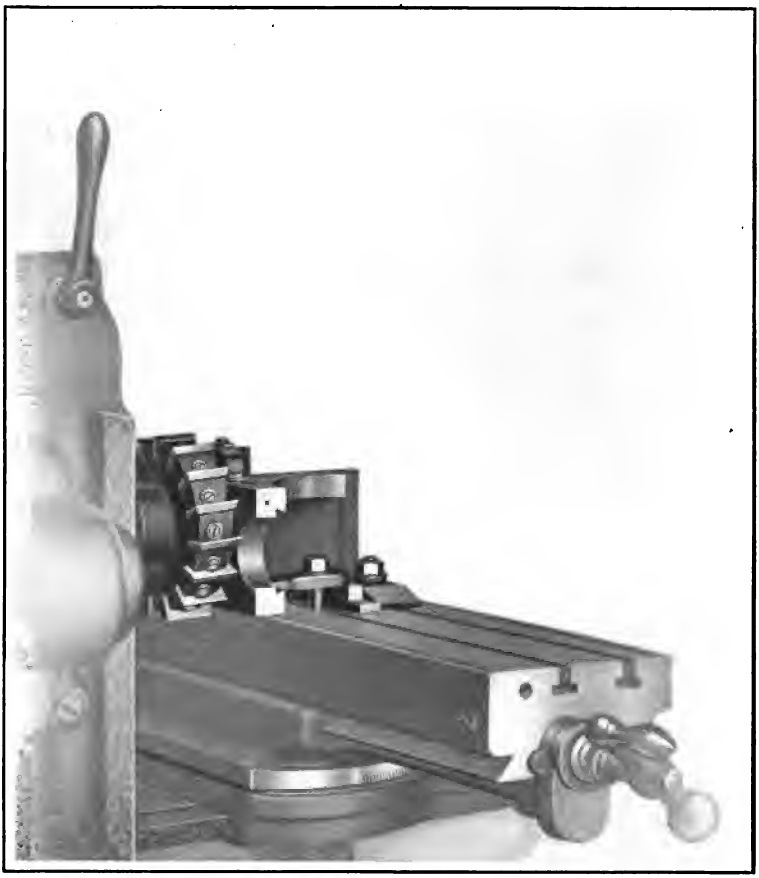


Milling Seat on Bottom of Bracket

The flat surface and V on a bracket can be milled in the manner shown in this cut. The bracket illustrated is of cast iron, and is clamped to the table by a bolt passing through a hole at the outer end of the casting, and a strap and bolt near the middle of the piece.

A 60° angular cutter is used and the table is fed longitudinally. A smaller cutter of the same angle can be used, but it will require several cuts to finish the piece.

This job, and others of a similar character, can also be done to good advantage on a vertical spindle milling machine or a horizontal machine fitted with a vertical spindle attachment.

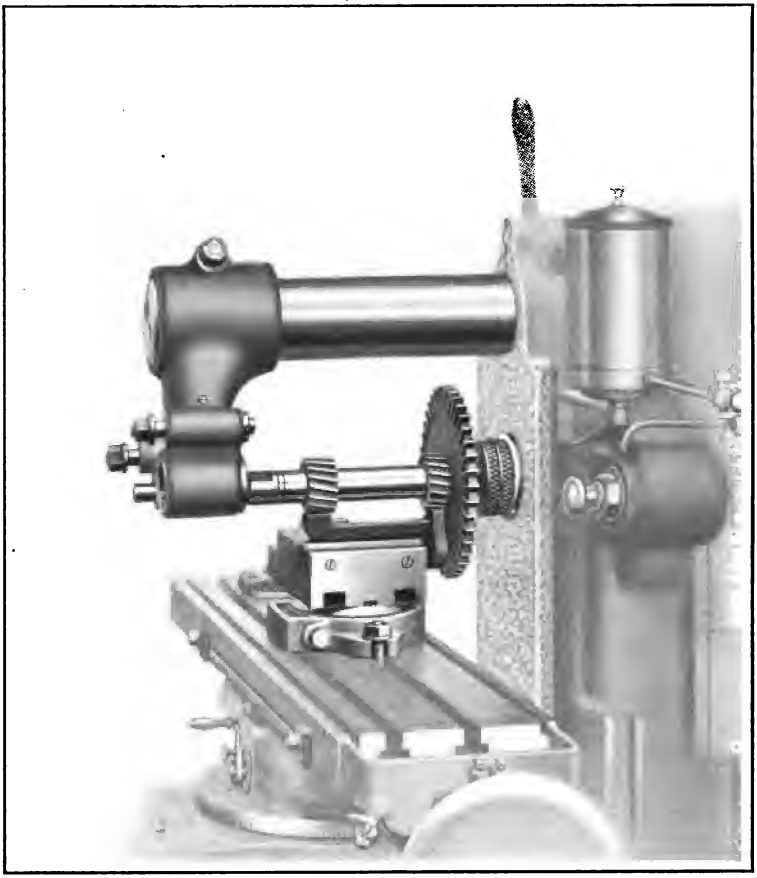


Face Milling Surface of Spiral Head Casting

This operation illustrates the use of a face milling cutter with inserted teeth for surfacing a piece of work.

The piece, which is of cast iron, is clamped to a knee to keep it square with the spindle. A strap in front prevents it being pushed away from the cutter, toward which there is a strong tendency.

The cutter is mounted directly on the nose of the spindle, and, in feeding, the work is moved longitudinally from right to left, or so as to force the work down against the table, rather than raise it. Only one cut is taken over the surface.

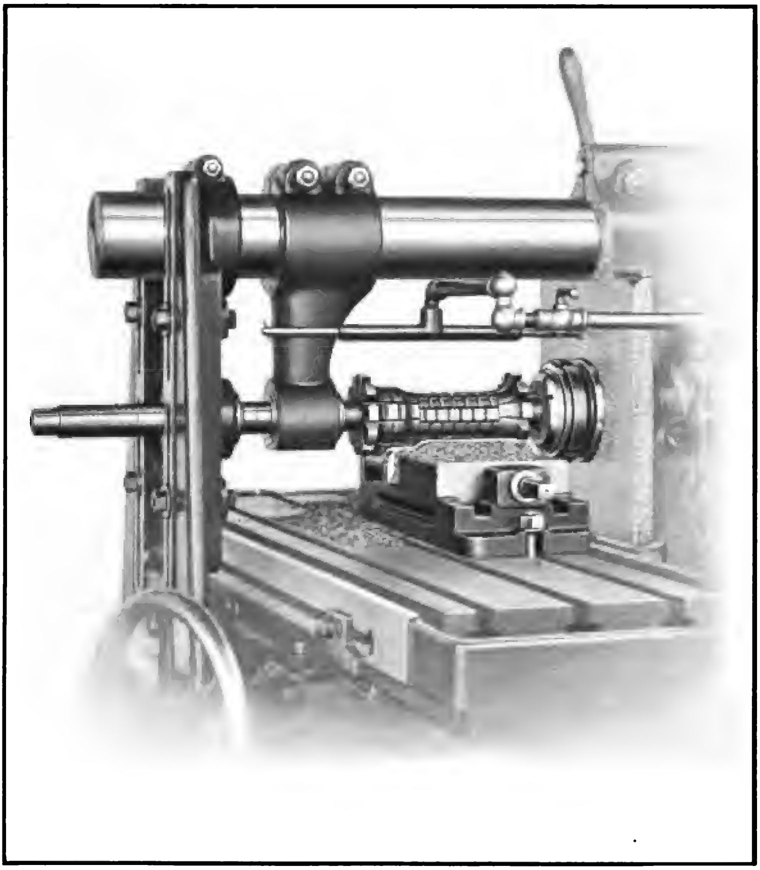


Milling Three Surfaces at one Setting

An example of light gang milling is shown in the accompanying cut. The two top surfaces and one end of the casting are being milled simultaneously by the use of two plain milling cutters, and a larger side milling cutter.

The two plain milling cutters are $2\frac{1}{2}''$ diameter, $1\frac{1}{4}''$ and $\frac{7}{8}''$ wide respectively; and the side milling cutter is $8''$ in diameter. To equalize the cutting speeds due to the wide difference between the diameters of the cutters, the large one is made of high speed steel, and the small ones of carbon steel.

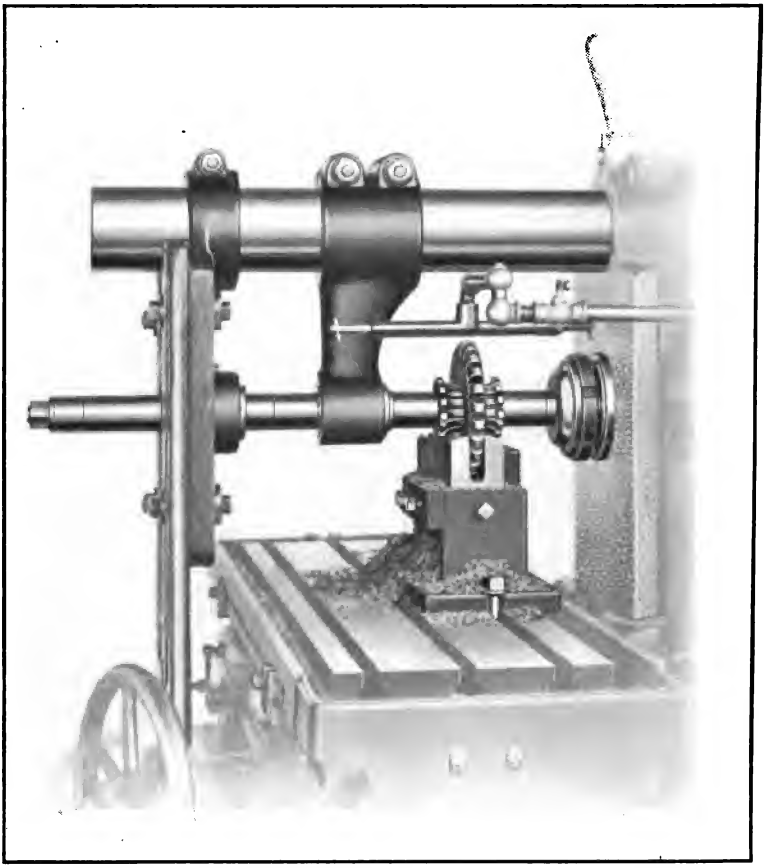
If only one or two pieces are wanted, this work can be done more speedily with an end mill, as it takes more time to set up and adjust the three cutters shown above than would be required for making special settings with an end mill.



Milling Outline on Reverse Gear Plates on a No. 2 B Heavy Plain Milling Machine

These plates are used on the spiral head to support the intermediate, or reverse gear. Before milling, a hole is drilled at each end of the plate, and then several plates are strung on rods. The ends of the rods are allowed to protrude, and slots are cut in the vise jaws to receive them. When one side of the plates is milled, the vise is unclamped and the plates are turned over, dropping the ends of the rods again into the slots in the vise jaws. The other side of the plates is then milled, producing the entire outline of several plates at two cuts and insuring duplication.

The outline is cut from the solid, and the material is steel, hence the cut is a heavy one. Lard oil or soda water is used as a cutting lubricant.

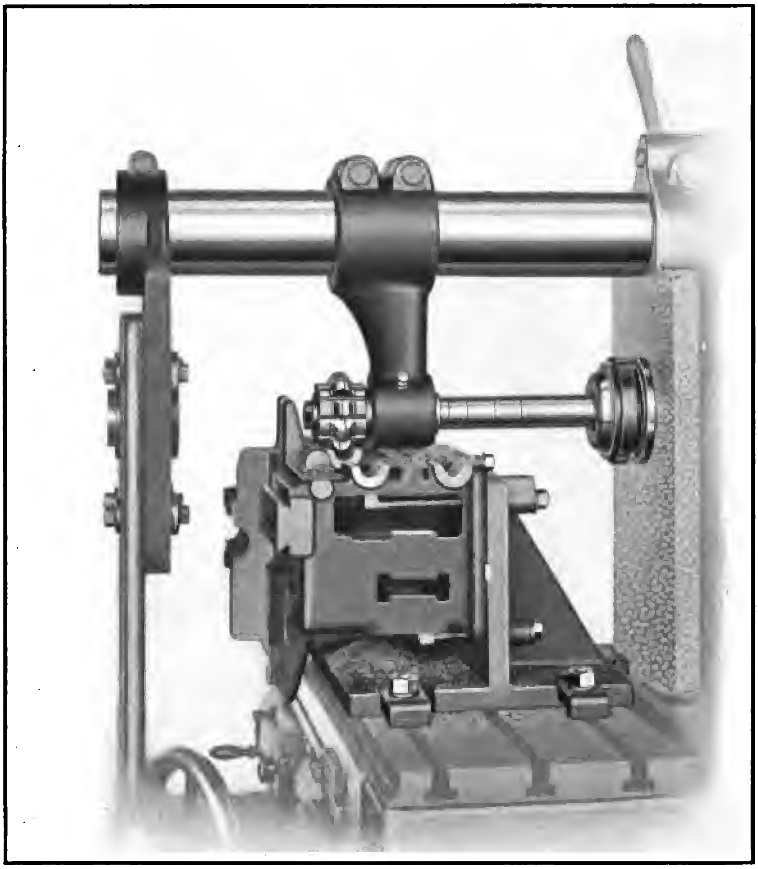


Milling End and Slot in Spiral Head Work Drivers on a No. 3 B Heavy Plain Milling Machine

Several of these work drivers are placed in the special fixture shown and clamped by means of the set screws at the side and end.

The cutter at one traverse mills the curved end and the deep slot in the plates. Then the set screws are slackened, each plate is reversed in the fixture, and the other ends are milled to duplicate the first.

The middle cutter is $7\frac{1}{2}''$ in diameter, and as the cut is taken from solid steel, a heavy machine with rigid support for the cutter arbor is required. Lard oil or soda water is used as a cutting lubricant in this operation.

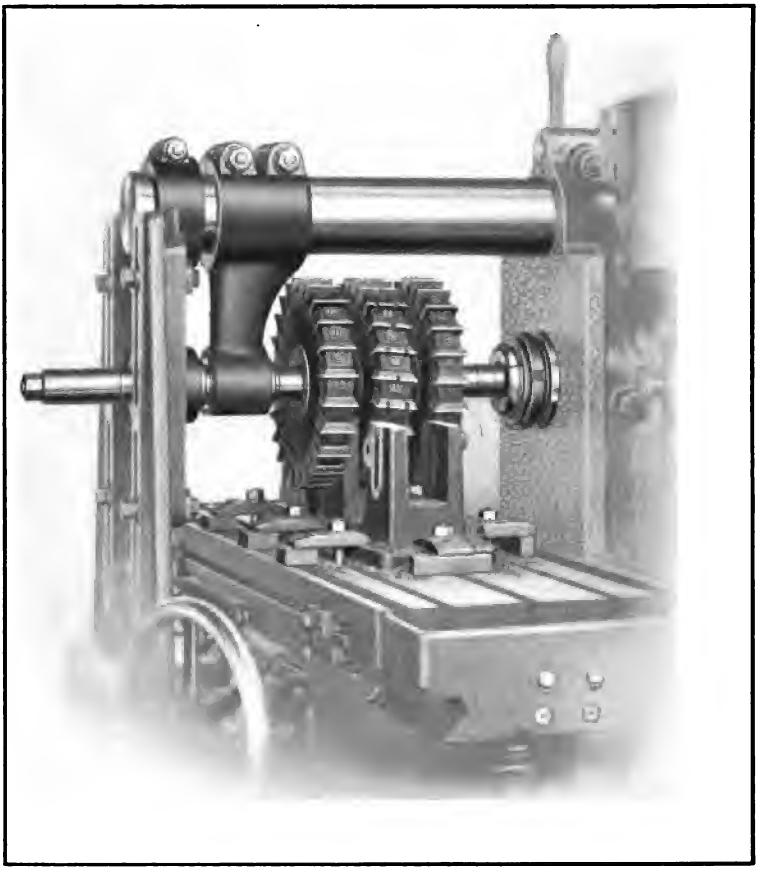


Milling Bearings on Automatic Screw Machine Bed on a No. 3 B Heavy Plain Milling Machine

It is the usual practice to put the caps on bearings, and bore them out, but this operation shows how bearings can be milled to good advantage. The caps can be milled at another operation so accurately that it is only necessary to pass a reamer through the bearings after the caps are put on to line them up exactly.

The cutter is made in two parts that are interlocking, and thin washers may be packed between to maintain the correct diameter.

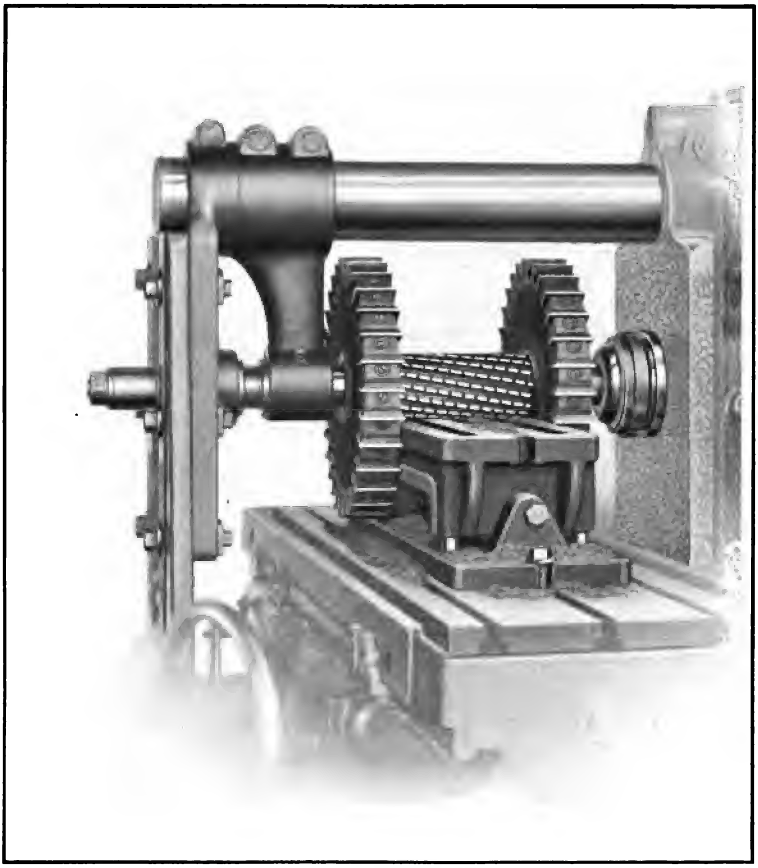
It should also be noted that the cutter has to be located at the end of the arbor because of the high projection on the casting.



Milling Sides of Foot-stock for Spiral Head on a No. 3 B Heavy Plain Milling Machine

This operation is of interest largely because the height of the sides milled is such that a gang of cutters of unusually large diameter is required. Three castings are lined up, strapped to the table, and milled at one cut. The outsides of the uprights are surfaced, and the space between is cut to the required width.

The cutters employed are inserted tooth side milling cutters 12 inches in diameter. Teeth are set parallel with the axis in the outside cutters, as their width is not great. In the middle cutter, which is wider, the teeth are set at an angle to give a shearing cut, and are nicked to break up the chips.



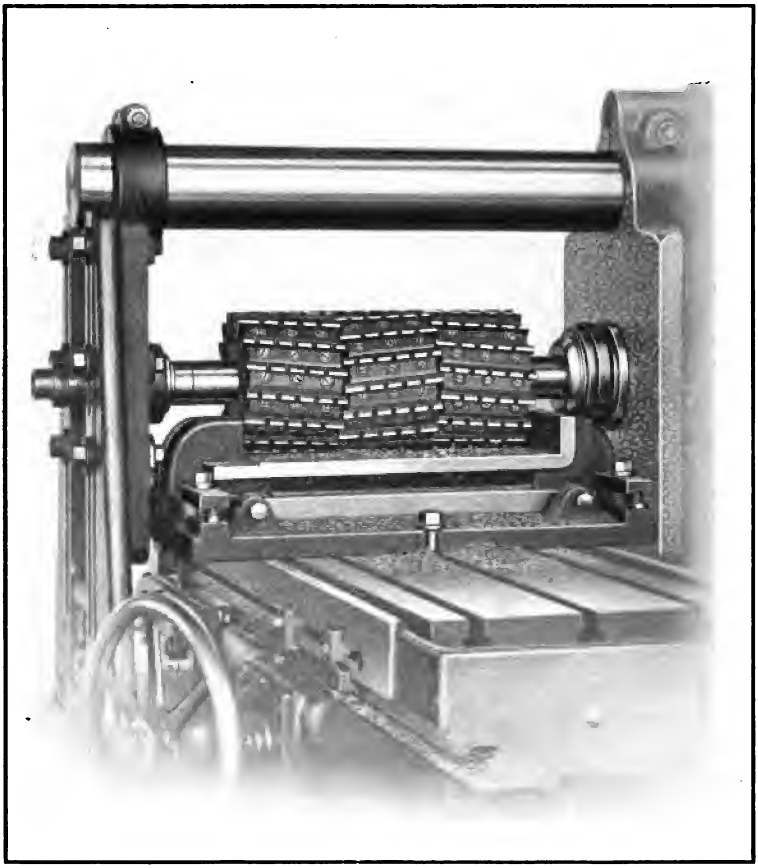
Surfacing Bottom and Sides of Milling Machine Vise Base on a No. 4 B Heavy Plain Milling Machine

The possibility of milling the deep sides of a casting, and at the same time surfacing the bottom, is illustrated in this cut.

A special fixture is employed to hold the piece, which is supported on three pins and located in position against stops. Set screws at both ends of the fixture clamp the piece.

The two side milling cutters shown are 16 inches in diameter, and the nicked tooth spiral cutter in the middle is 4 inches in diameter.

Only one casting can be milled at a time, owing to the distance it takes for the large cutters to clear the work at the beginning and end of the cut.

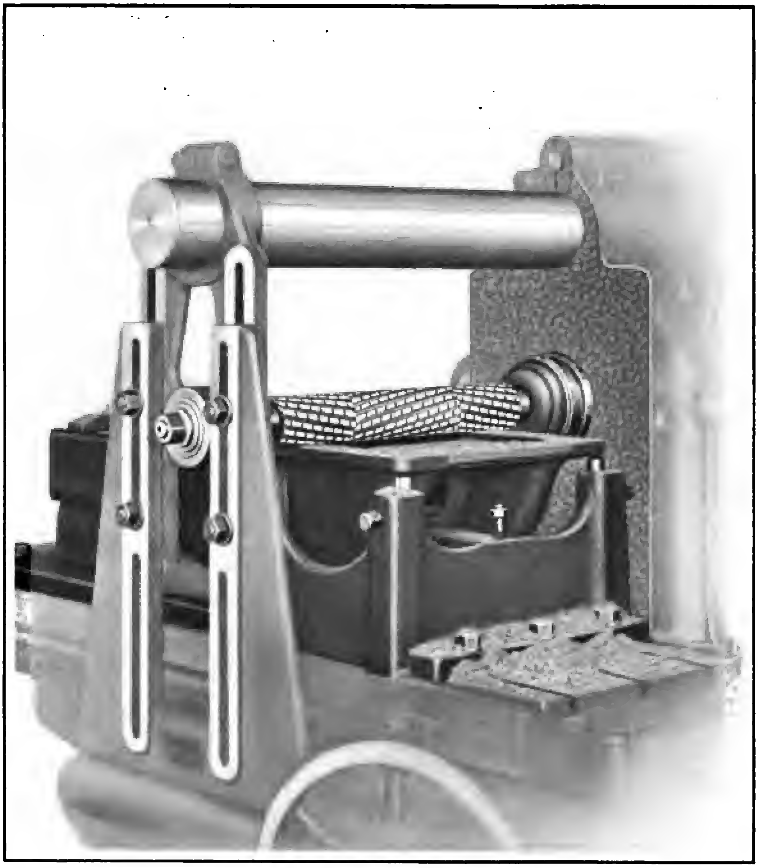


Milling Slide Seat of Vise on a No. 4 B Heavy Plain Milling Machine

This is the second operation on the casting shown in the preceding illustration. The cut is a simple, but heavy one, being 17 inches wide and $\frac{3}{32}$ of an inch deep.

Interlocking inserted tooth milling cutters, 8 inches in diameter, are used, the large diameter being necessary because of the height of the casting at the ends.

Where the end thrust on the arbor cannot be equalized, the greatest thrust should be toward the spindle nose. Thus in the above operation, two right-hand angle cutters are used against one left-hand, and the greatest thrust is toward the spindle nose.

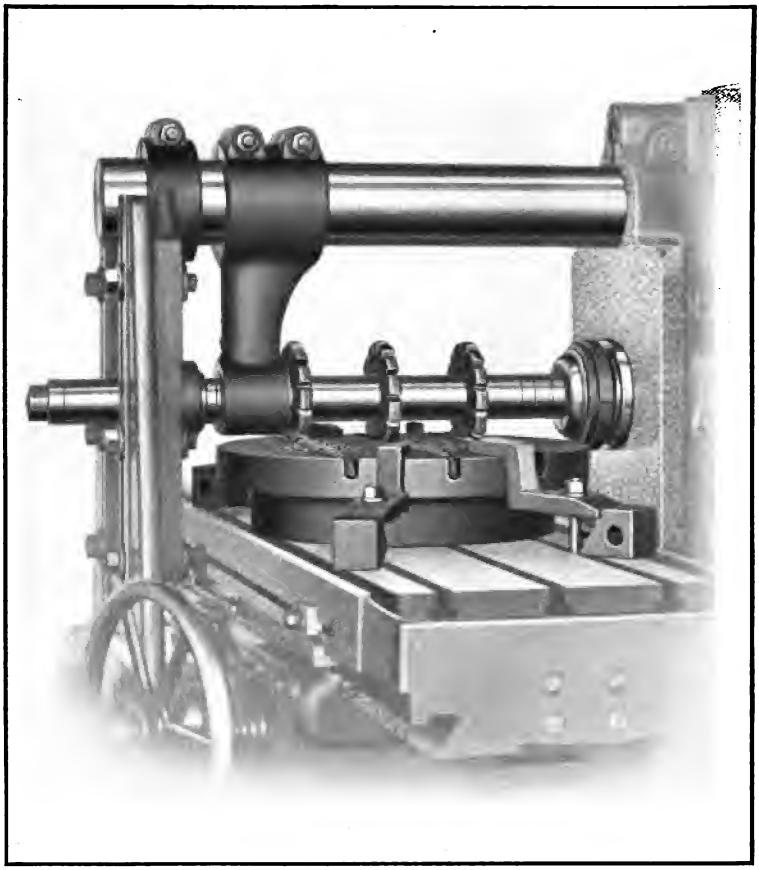


Surfacing Large Casting on a No. 4 B Heavy Plain Milling Machine

An excellent example of heavy, plain gang milling is shown in this illustration. The surface being milled is $15\frac{1}{2}''$ wide, and the casting is held in a special fixture.

The table is fed longitudinally against the direction in which the cutters revolve. As the cut is comparatively heavy, nicked tooth cutters are employed, and it will be noticed that the thrust is mostly toward the spindle nose.

For such work as this, where considerable power is required to drive the cutters, the Constant Speed drive machine is superior to the Cone drive type.



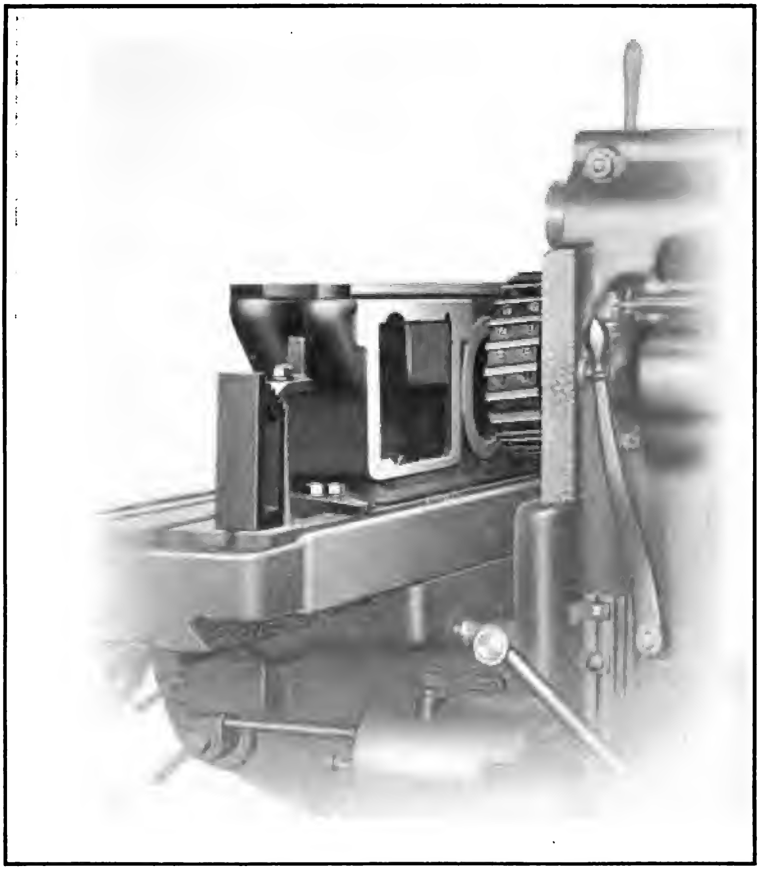
Cutting Slots in Circular Milling Attachment Table on a No. 4 B Heavy Plain Milling Machine

Three parallel slots are cut in the top of this table by spacing three cutters on the arbor by means of collars.

Considerable power is required for the operation, as the slots are cut from solid stock to the depth of $\frac{7}{8}$ of an inch, and $\frac{9}{16}$ of an inch wide.

Specially shaped straps are necessary to fasten the work to the table, in order to make use of cutters of small diameter.

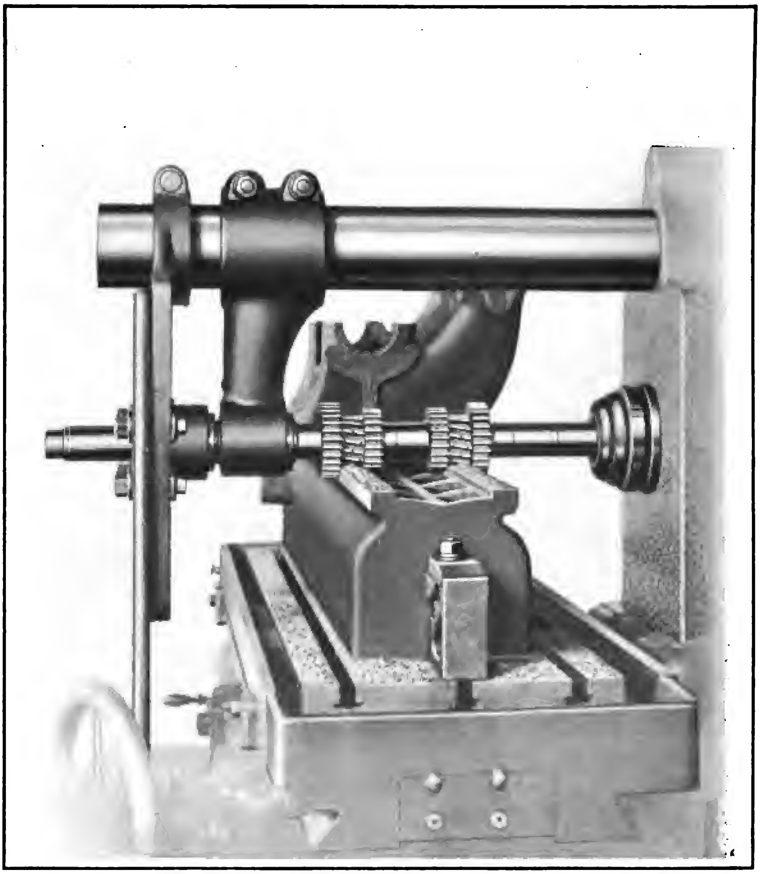
The cutters employed are regular stocking cutters 6 inches in diameter, and are rigidly supported on the arbor.



Face Milling Front of Grinding Machine Bed on a No. 3 B Heavy Plain Milling Machine

Jobs similar to this are done on the planer in many shops, but by setting the work up as shown, it is often possible to get a greater production from the milling machine.

The bed is lined up against a parallel inserted in one of the table T slots, so that there is no trouble lining up each successive casting. The saddle does not have to be readjusted for depth of cut each time. Straps at each end hold the piece on the table, and stops set in the table T slots prevent the tendency of the casting to slip, due to the action of the cutter.

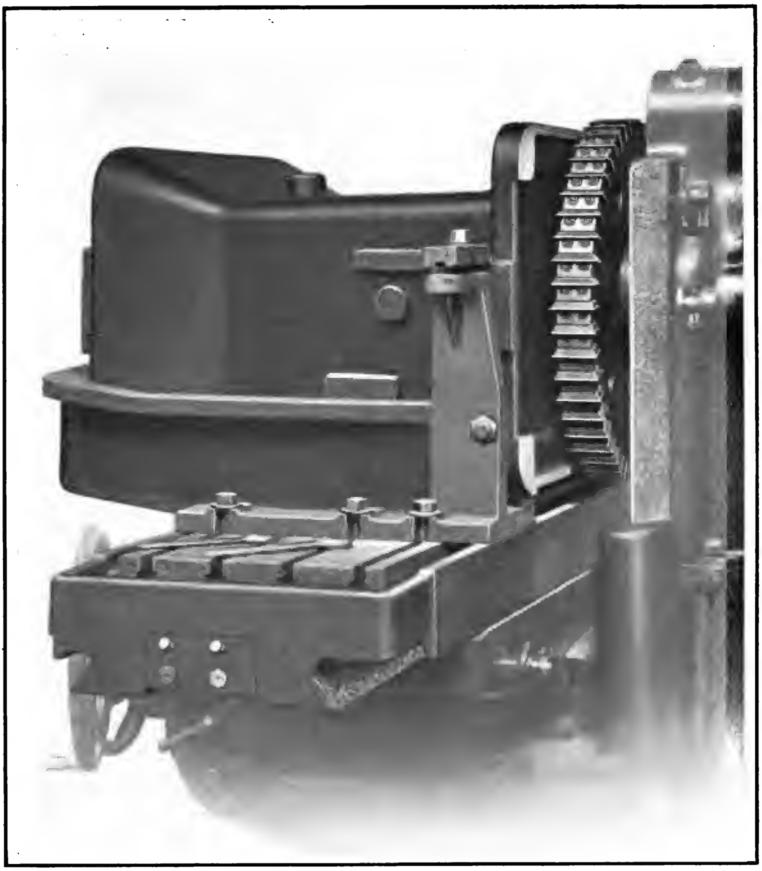


Milling Ways on a Screw Machine Bed on a No. 4 B Heavy Plain Milling Machine

The value of gang milling, and the advantages of the milling machine over the planer, are very apparent in this operation, for it is essential that the ways on every bed be exact duplicates in width and distance apart. Once the gang of cutters is accurately set, each succeeding casting must necessarily be a duplicate of the first.

The bed has a boss cast on each end by means of which it is clamped directly to the table. After milling, the two bosses are taken off.

The gang of cutters is composed of four side milling cutters, and two plain spiral milling cutters with nicked teeth. The arbor is firmly supported in the arm braces, and the arbor support is employed to bring a bearing nearer the cutters.



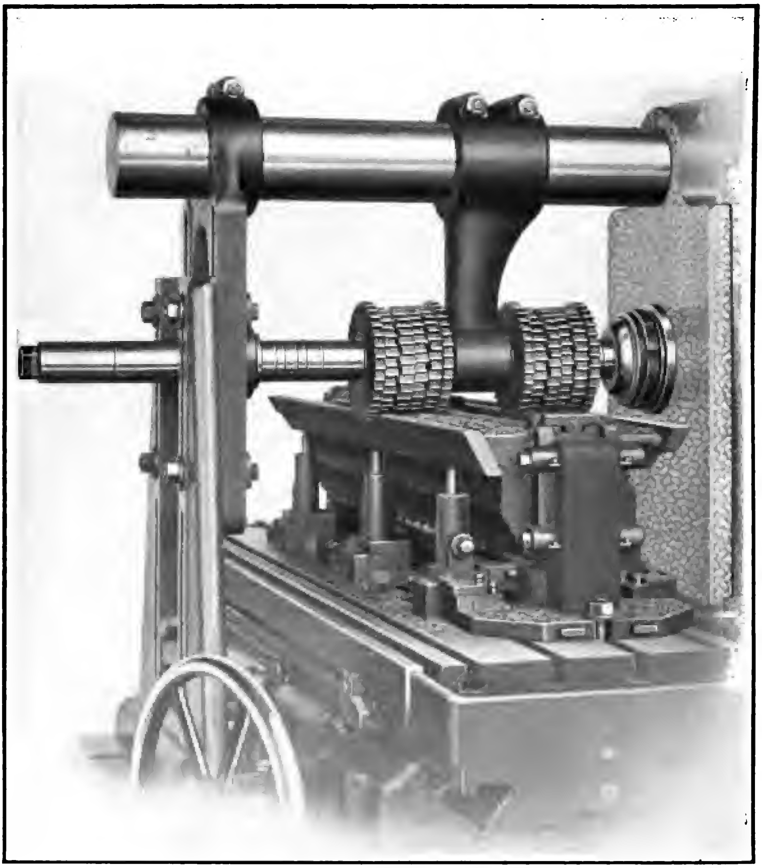
Surfacing Bottom of Screw Machine Bed on a No. 5 B Heavy Plain Milling Machine

This illustration shows the possibilities of the milling machine for doing work that might be termed in many shops as suitable for the planer only.

The extreme weight, large size and powerful leverage due to the large overhang of the piece, are all factors that serve to make this an unusual milling job that requires a rigid machine.

The work and fixture together weigh over 1000 pounds, and the piece as it is fastened to the table is 25″ high, and extends 35″ out from the cutter.

Another unusual point is the size of the inserted tooth face milling cutter, which is 26″ in diameter.

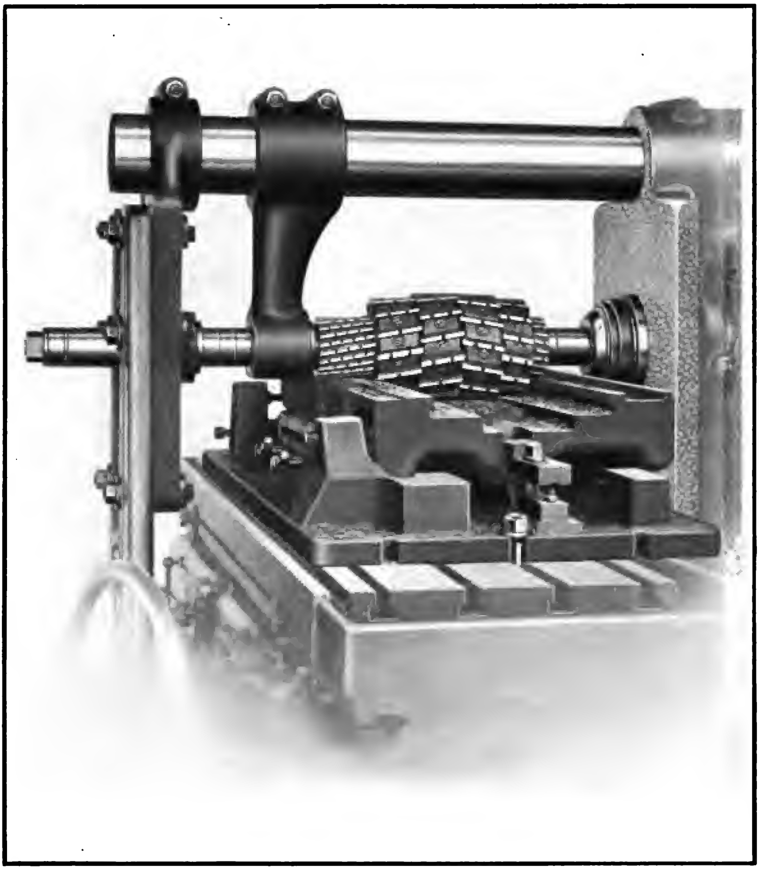


Milling Pair of Grinding Machine Tables on a No. 5 B Heavy Plain Grinding Machine

Where the size of machine and character of work permit, it is very advantageous to mill more than one piece at a time. This operation illustrates how two plain grinding machine tables are milled simultaneously.

The two tables are held in a fixture, the essential features of which are plainly apparent in the cut. There are two sets of cutters made up of plain milling cutters and interlocking mills.

Another feature of this operation is the placing of the arbor support between the two sets of cutters.



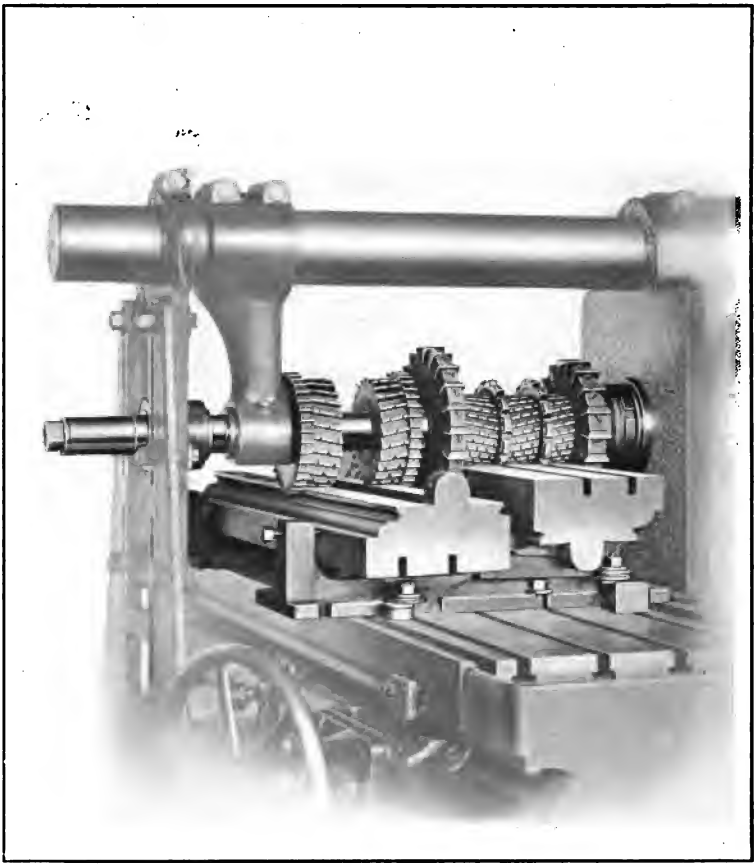
Milling Saddle of Vertical Spindle Milling Machine on a No. 5 B Heavy Plain Milling Machine

Milling machines are employed wherever possible in manufacturing parts of milling machines in our works. The operation above shows one example of this.

The width of cut on this saddle is 17 inches, and $\frac{3}{16}$ of an inch of stock is removed, making a heavy cut.

The work is held in a special fixture, as it can be more firmly clamped, and more quickly put in place and removed from the table.

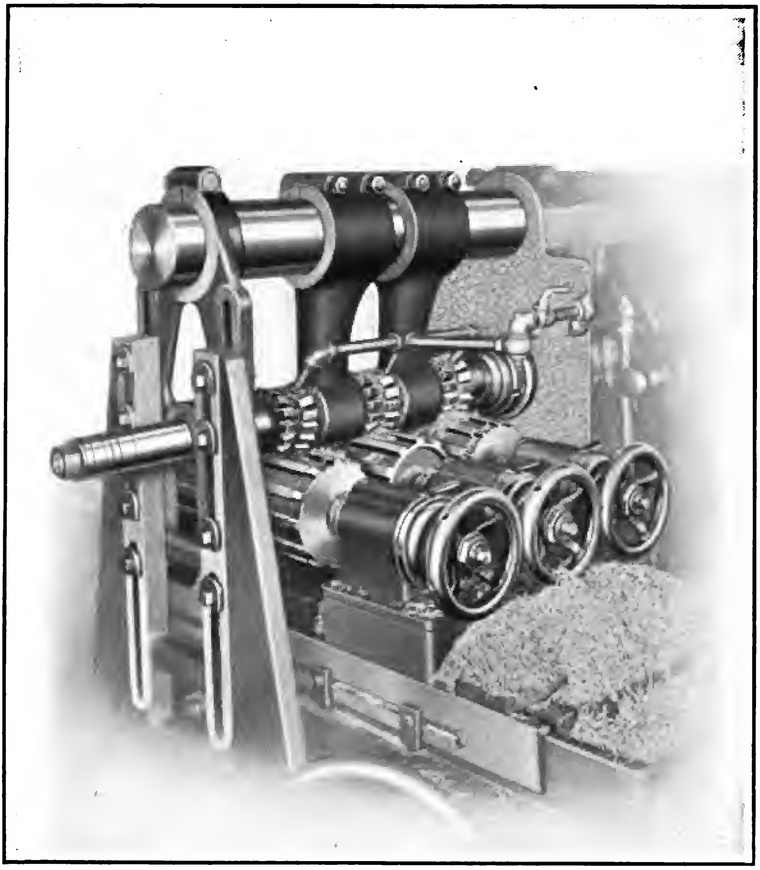
All of the cutters have nicked teeth, and the larger ones have inserted teeth. It should also be noted that end thrust on the arbor is equalized by using cutters of both right and left-hand angle teeth.



Heavy Gang Milling of Milling Machine Tables on a No. 5 B Heavy Plain Milling Machine

The job shown above is that of milling the cast iron tables of small milling machines, and it is an interesting example, illustrative of the economy of gang milling. The top of one table and the bottom of another are milled simultaneously. The castings are held in a special fixture, and when one cut is taken, the piece at the left is removed, the one on the right turned over so that the ways on the bottom can be cut, and a new casting is put on the right-hand side of the fixture.

The table is fed longitudinally from left to right, and the cutters comprise four side milling cutters, one $9\frac{1}{2}''$, one $11\frac{1}{2}''$, and two $7\frac{7}{8}''$ in diameter; five plain milling cutters, two $7\frac{1}{8}''$, and three $4\frac{3}{4}''$ in diameter; and two slotting cutters, $6\frac{29}{32}''$ in diameter.



Cutting Two Grooves in Six Steel Cores at One Traverse on a No. 5 B Heavy Plain Milling Machine

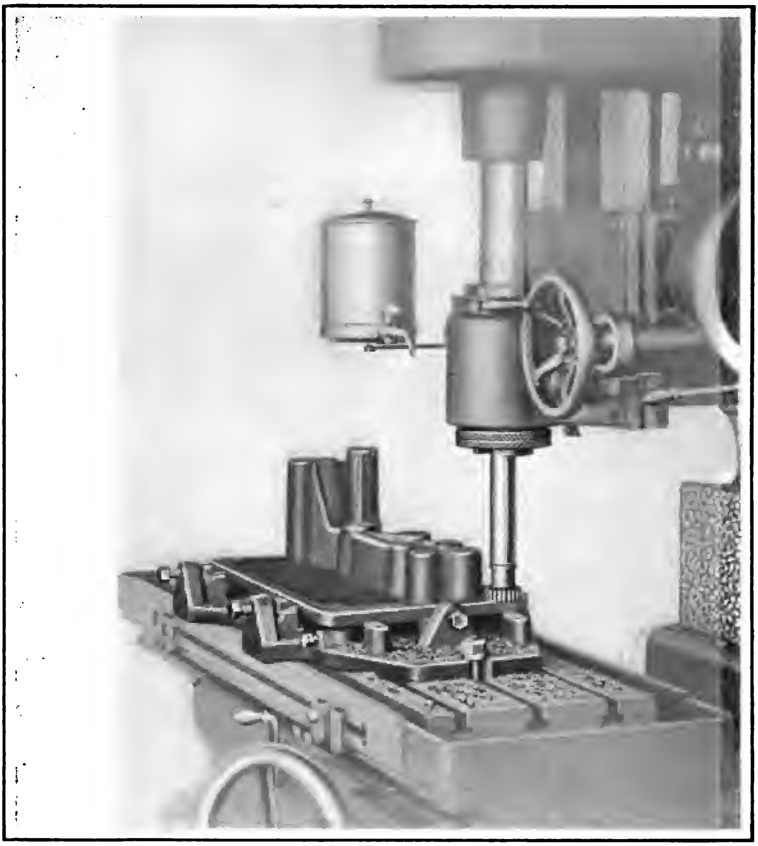
This illustration shows an unusually heavy milling operation, consisting of cutting two grooves, each 1.17″ wide and $\frac{5}{16}$″ deep, in six steel forgings at one traverse of the table.

Three sets of index centres of a special design are employed, and two steel cores are mounted on the arbor on each pair of centres.

The cutters are of a special form to cut two grooves and the top of the intervening space between the grooves.

For such a cut as this, a large arbor is required, and it must be very rigidly supported; intermediate arbor supports are, therefore, placed between the cutters.

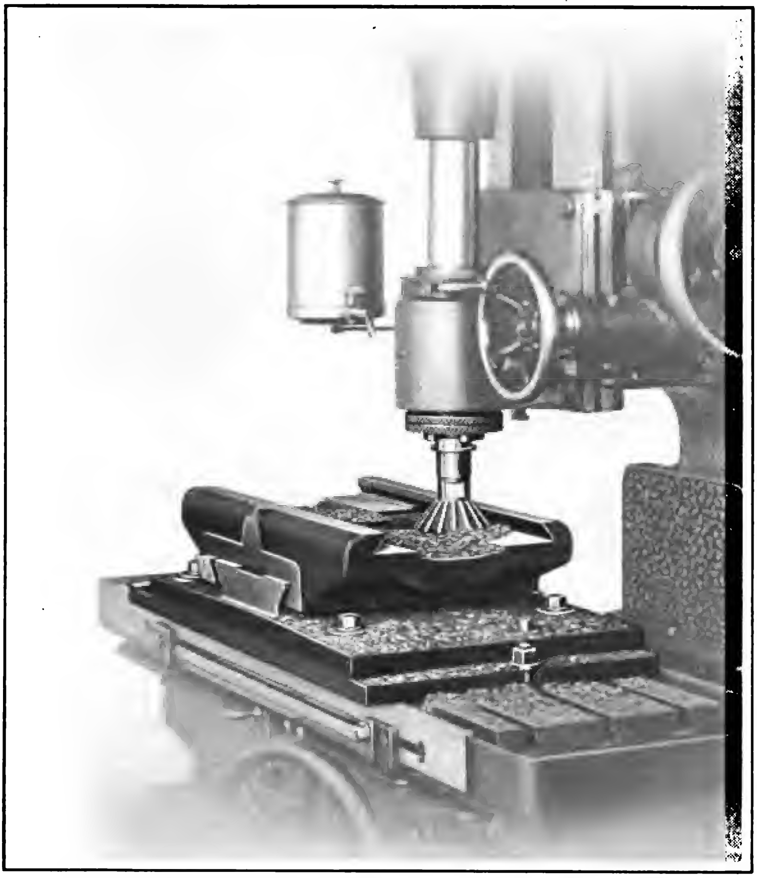
Lard oil is used as a cutting lubricant.



Surfacing Face of a Grinding Machine Apron on a No. 3 Vertical Spindle Milling Machine

A vertical spindle milling machine is peculiarly adapted to work having a long projecting hub, or where it is necessary to surface off some part inside, such as in gear cases. The operation above is typical of such work, and shows a casting that must be milled all around the outside edge.

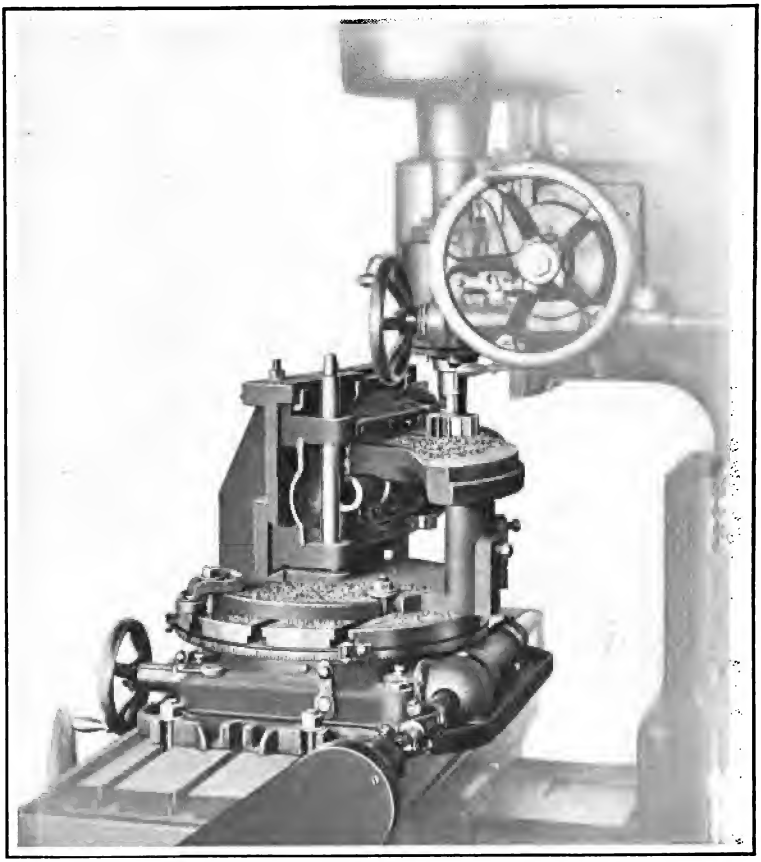
The casting is clamped in a special fixture, and a shell end mill is employed. The outline of the edge is followed by using the horizontal and transverse table feeds alternately for the different sides.



Milling a Dovetail in Plain Milling Machine Saddle on a No. 3 Vertical Spindle Milling Machine

The casting is held on a special fixture which has a slide corresponding to the slide on the top of the knee of the milling machine. The piece can be removed by simply loosening the gib.

The top plate of the fixture also swivels, so that one side of the ways can be milled on an angle for a taper gib. Both operations are, therefore, completed at one setting of the fixture, thus insuring the surfaces being milled in relation to each other. A 50° angular cutter is used for this operation.

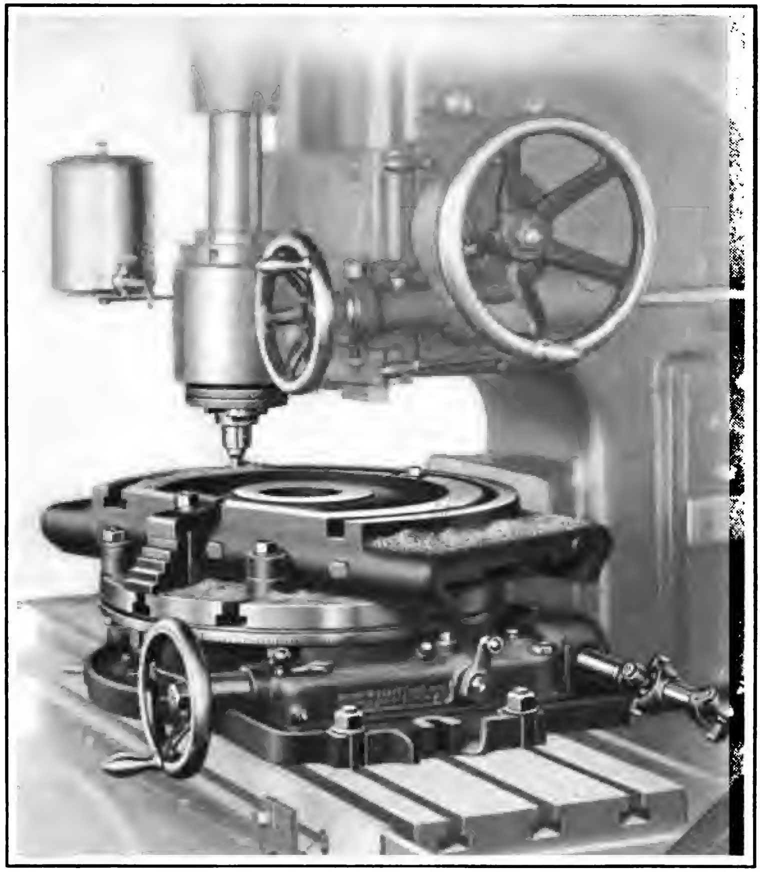


Surfacing and Milling Edge of Curved Casting on a No. 3 Vertical Spindle Milling Machine

This illustration shows the use of a power-driven circular milling attachment, in connection with a vertical spindle milling machine for milling the surface and edge of a cutter carriage of an automatic gear cutting machine.

The special fixture employed is more for the purpose of milling the outside curved edge of the casting than for the operation shown. It has a way cut to correspond to that on the back of the casting, and an arbor inserted through two holes in the piece and into the centre of the circular milling attachment insures the outer edge being milled concentric with the holes.

All necessary movement is obtained from the circular attachment.

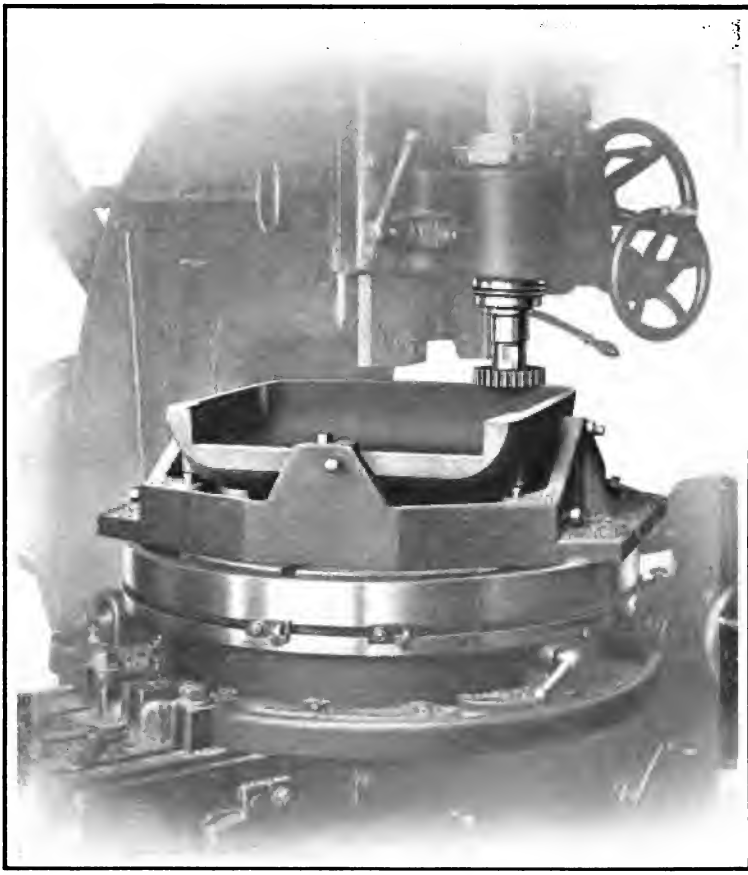


Cutting a Circular T Slot in Universal Milling Machine Saddle on a No. 3 Vertical Spindle Milling Machine

The operation shown above illustrates another excellent example of the use of the circular milling attachment in connection with a vertical spindle milling machine, for cutting the circular T slot in the saddle of a universal milling machine.

The piece of work is centred by placing it over a stud and bushing inserted in the hole in the centre of the circular attachment table. It is prevented from swinging by four bolts with washers, two of which are shown, and a strap from a stepped block across to the casting on each side fastens it to the table.

The first, or plain, slot is cut out on a boring mill or can be milled at the same setting shown above, using a two-lipped end mill, which is then replaced by the T slot cutter.

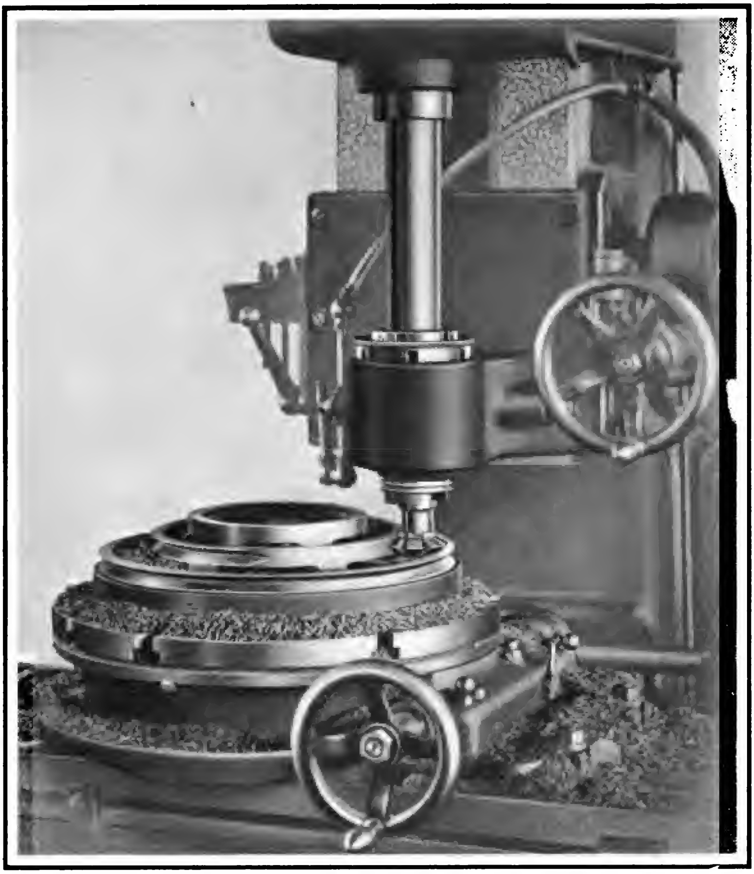


An Interesting Use of a Circular Milling Attachment on the No. 3 Vertical Spindle Milling Machine

Surfacing such a casting as this would ordinarily be done by following the outline of the piece of work, using the longitudinal and transverse automatic table feeds. But this necessitates shifting the feeds at each corner of the casting. A better way was found when the casting and fixture were clamped to the table of a circular milling attachment and fed in a circular path beneath the cutter.

The shorter distance the mill has to travel, the time saved in shifting feeds, and the fact that the operator does not have to give his undivided attention to the job, are all important advantages.

The metal is $\frac{1}{2}''$ thick. By the usual method, it is difficult to secure the flat, oil-tight surface that is easily obtained in the way described above.

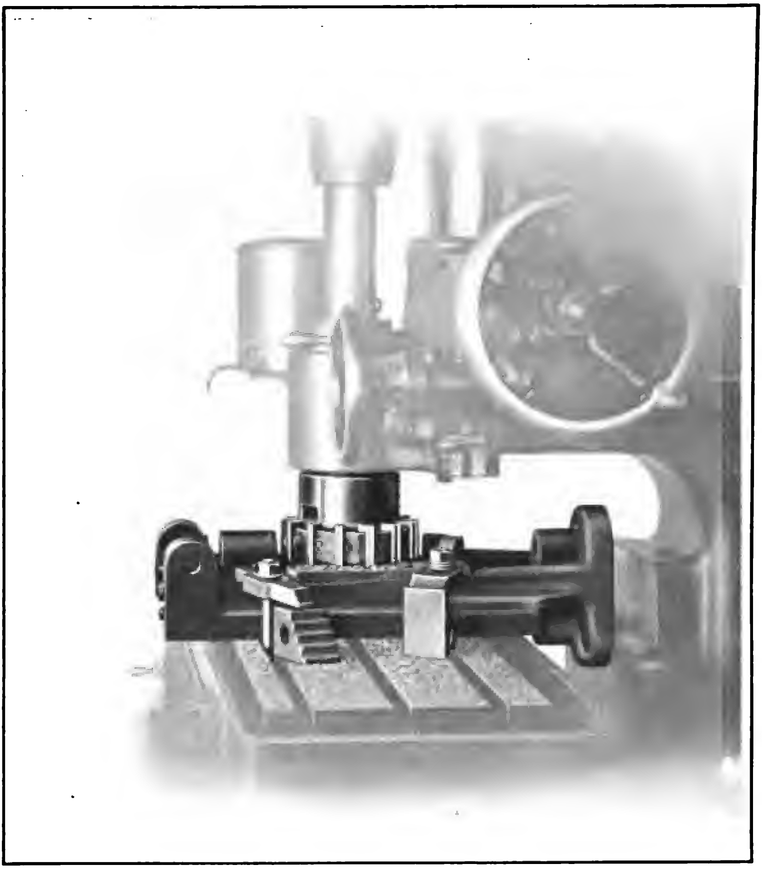


Milling Grooves in Rim of Pulley on the No. 3 Vertical Spindle Milling Machines

Here a vertical spindle machine equipped with a circular milling attachment is shown milling belt grooves in the rim of a three step pulley.

The pulley is easily fastened in place and a continuous cut is taken around the rim, using the automatic feed of the attachment. The knee is then lowered to bring the cutter at the right height for the next smaller step and the table is moved longitudinally to get the correct depth of cut. This operation is repeated for the smallest step and the piece is finished.

This operation can also be done on a horizontal milling machine when equipped with both vertical spindle and circular milling attachments.

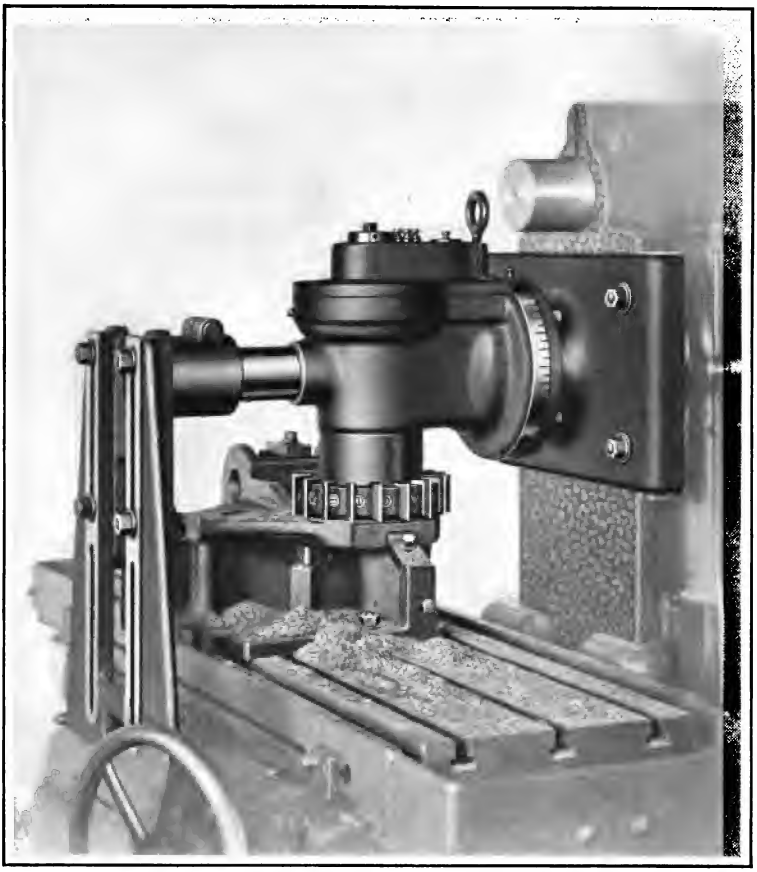


Milling a Plain Surface on a No. 3 Vertical Spindle Milling Machine

It is advisable in milling castings such as that shown, to do the work on a vertical spindle machine, as it is much more convenient. If a horizontal spindle machine is employed, and the work is clamped to the table, plain cutters of unusually large diameter are required, and when a face milling cutter is used, the work must be clamped to a knee. This, too, is unhandy when the casting is somewhat unwieldy.

The piece of work illustrated is of cast iron, and it is fastened directly to the surface of the table by means of straps extending from step blocks to the casting and secured in place by bolts set in the table T slots.

The face mill employed has inserted teeth. The table may be fed longitudinally in either direction.

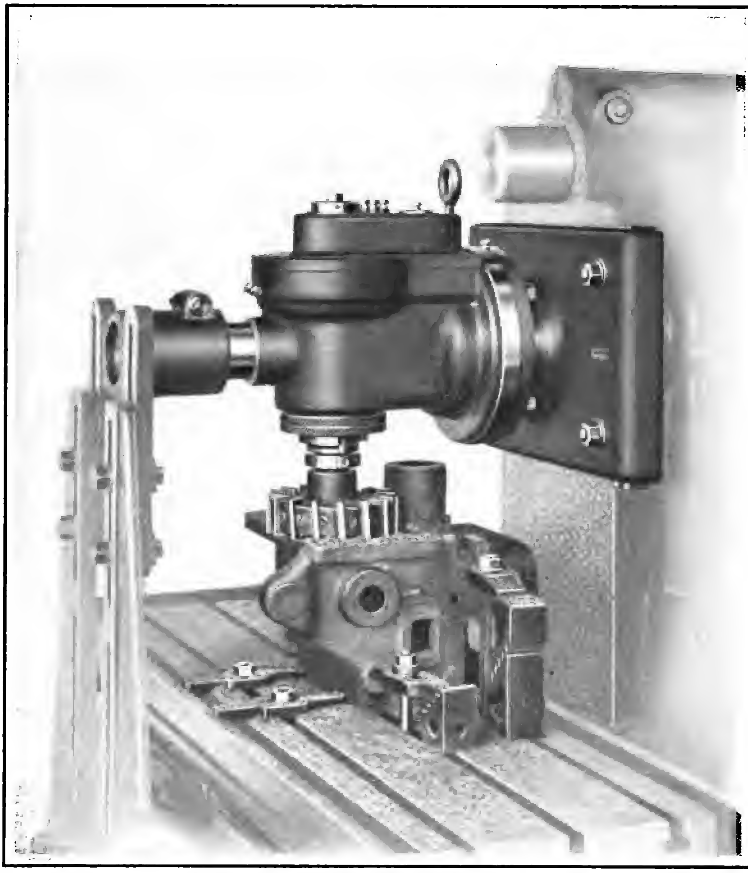


Face Milling, Using Heavy Vertical Spindle Attachment on a No. 4 B Heavy Plain Milling Machine

It will be seen from the above cut that in shops where the volume of work does not warrant installing a vertical spindle milling machine, the operation that would generally be done on that machine can be done on a horizontal spindle machine equipped with a vertical spindle attachment. The illustration shows the heaviest style of attachment.

The operation is that of face milling a surface on a cast iron piece which is held in a special jig upon the table.

The cutter is of the inserted tooth style, $9\frac{1}{2}''$ in diameter. The table is fed from left to right on account of projections at end of casting.



Face Milling, Using Heavy Vertical Spindle Attachment on a No. 4 B Heavy Plain Milling Machine

This operation is essentially the same as the one just described, with the exception that the casting in the first instance was fastened in a special fixture, while in this case it is clamped directly to the table and the cutter is held on an arbor.

The method of clamping needs little explanation, as it is very clearly shown in the illustration.

If it were not for the height of the hub at the right of the cutter, this job could easily be done without the attachment with plain milling cutters.

The cutter is $7\frac{1}{2}''$ in diameter and has inserted teeth.

CHAPTER VIII

Milling Operations—Gear Cutting

We do not propose in this chapter to go deeply into the subject of gearing, for it would be impossible to properly treat it in so limited a space. Neither do we intend to describe the manner in which gears are cut on automatic gear cutting machines designed especially for that purpose. Our object is rather to give a few practical points applying to the cutting of different kinds of gears on a milling machine, and to show illustrations of how various gear cutting jobs and work of a kindred nature can be set up. Anyone desirous of making a detailed study of gears is referred to the many books now published that are devoted exclusively to the subject, among which are our "Practical Treatise on Gearing," and "Formulas in Gearing."

Cutting Spur Gears. The first things that it is necessary to know in order to cut a spur gear, are the pitch, either diametral or circular, and number of teeth required. These must be had in order to select the correct cutter to use.

We make eight cutters for each pitch, as follows:

No. 1	cutter	will	cut	wheels	from	135	teeth	to	a rack
No. 2	"	"	"	"	"	55	"	"	134 teeth
No. 3	"	"	"	"	"	35	"	"	54 "
No. 4	"	"	"	"	"	26	"	"	34 "
No. 5	"	"	"	"	"	21	"	"	25 "
No. 6	"	"	"	"	"	17	"	"	20 "
No. 7	"	"	"	"	"	14	"	"	16 "
No. 8	"	"	"	"	"	12	"	"	13 "

For those who require a finer division of the number of teeth to be cut with each cutter than can be cut with the regular numbers listed above, we can furnish half numbers in cutters from 2 to 8 pitch inclusive, as follows:

No. 1½	cutter	will	cut	wheels	from	80	teeth	to	134 teeth
No. 2½	"	"	"	"	"	42	"	"	54 "
No. 3½	"	"	"	"	"	30	"	"	34 "
No. 4½	"	"	"	"	"	23	"	"	25 "
No. 5½	"	"	"	"	"	19	"	"	20 "
No. 6½	"	"	"	"	"	15	"	"	16 "
No. 7½	"	"	"	"	"	13			

Care should be exercised that the teeth of a cutter selected are ground radially and equidistant, for the teeth are so formed that unless ground in this manner, the correct shape is not produced in the work.

If a universal milling machine is employed, the table should be set at exact right angles to the arbor by the graduations on the saddle. This precaution does not have to be taken on plain machines, as the table is fixed at right angles to the spindle or arbor.

Set Cutter Central. It is essential that the cutter be exactly central with the axis of the gear blank, especially when the gear is to be run fast, otherwise the gear will be cut "off centre," and will run more noisily in one direction than in the other. It may be set centrally as follows: Set the table or the cutter on the arbor as nearly as possible in position; fasten the gear blank, or preferably an odd blank of about the size of the gear to be cut, on an arbor and lock it in position on the centres. Take a single cut, then remove the blank from the arbor, turn it end for end and put it back on. Permit the blank to remain loose on the arbor, and see if the cutter will pass through the groove already cut without taking any stock off on either side. If the cutter is not exactly central, stock will be cut from the upper part of one side of the groove and from the lower part of the opposite side of the groove. If this is found to be the case, the table can be slightly adjusted to compensate for the error and another trial cut taken.

Some of the gear cutters made by us have a line on the tops of the teeth that is central with the form, and for ordinary slow running gears, the cutter may be centred by bringing this line to coincide with the centre in the spiral head or foot-stock.

Measure Blanks. Measure all gear blanks carefully. It is impossible to cut correct running gears from blanks that are of the wrong diameter unless the error is small. The amount of error allowable in the diameter depends upon the pitch of the gear; the heavier the pitch, the greater the allowable error. It is better to return to the lathe any blanks that are oversize and throw away those that are turned very much undersize. If blanks are only slightly undersize, they can be cut by making allowance for the error in setting for depth of teeth, and the resultant gears will run satisfactorily, though not perfectly.

Secure Blank on Arbor. The next important step is to see that the work arbor runs true and that the blank does not spring it when

forced or tightened. A good method of holding blanks is on arbors, such as our milling machine cutter arbors, that have a taper shank to fit the index spindle; the outer end of the arbor being supported by the foot-stock centre. Another way of holding blanks is by means of a shank arbor with expanding bushing, such as our gear cutting machine "work arbors." A nut is located on the arbor at each end of the bushing, one nut forcing the bushing up on the arbor and holding the blank, while the other pushes the bushing off the taper and releases the gear when finished.

If a common arbor and dog are used, care should be taken that the tail of the dog is fastened between the set screws provided on the spiral head, so there will be no backlash between the index spindle and work; also see that the dog does not spring the arbor when it is clamped.

Set Knee for Depth of Cut. The depth of cut is regulated by the height of the knee of the machine. To make this setting, the knee is brought up until the cutter just touches the blank. Then the blank is moved out from under the cutter and the knee is raised the number of thousandths of an inch required for the depth of tooth, which can be ascertained from the tables on pages 319 to 322, or by dividing the constant 2.157 by the diametral pitch.

When raising the knee, use the graduated dial on the vertical hand feed screw for a guide to get the required depth, but be sure to take out any backlash that may exist before making an adjustment.

Testing for Correct Depth. To make certain that the depth of groove cut is correct and the size of teeth accurate, cut two grooves into the face of the blank far enough so that the full form of the tooth is produced, and then measure the resultant tooth at the pitch line for thickness and the depth of the tooth to the pitch line. The correct thicknesses of spur gear teeth of different pitches at the pitch line are given in the tables on pages 319 to 322, or can be found by dividing the constant 1.57 by the diametral pitch.

By cutting only part way across the face of the blank the trial grooves can be quickly made and measured. If, on the other hand, the grooves are cut across the full width of the face, there is liability, under some conditions, of more stock being taken from these grooves when the actual cutting is commenced and the cutter is allowed to pass through the same grooves a second time, thus making these grooves too deep.

Chordal Thickness of Gear Teeth. When accurate measurements of gear teeth are required, it is necessary to work to the chordal

figures, t'' = thickness of tooth and s'' = distance from chord t'' to top of tooth (See Fig. 60).

These dimensions vary from the standard dimensions of tooth parts shown on pages 319 to 322. The fewer the number of teeth in the gear, the greater the variation.

The Table of Chordal Thickness t'' and Distances from Chord to top of Tooth s'' on page 323 gives these dimensions for gears of 1 diametral pitch. To obtain t'' and s'' for any diametral pitch, divide the figures given in the table opposite the required number of teeth, by the required diametral pitch.

Example: Find t'' and s'' for a gear 5 diametral pitch, 23 teeth.

$1.5696 \div 5 = .3139 = t''$.
$1.0268 \div 5 = .2054 = s''$.

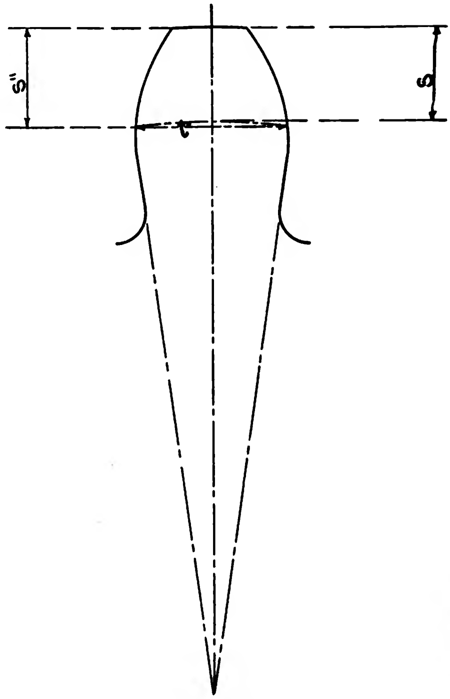


Fig. 60

To obtain t'' and s'' for any circular pitch, multiply the figures given in the table opposite the required number of teeth, by the addendum s (taking s from the Table of Tooth Parts, pages 319 and 320).

Example: Find t'' and s'' for a $\frac{3}{4}''$ circular pitch gear, 15 teeth.

$1.5679 \times .2387 = .3743 = t''$.
$1.0411 \times .2387 = .2485 = s''$.

If number of teeth required is not shown in table, take the nearest number of teeth.

An accurate and convenient tool for taking the measurements of gear teeth is shown in Fig. 61. With this gear tooth vernier, the distance from the top of the teeth to the pitch line, and thickness at the pitch line, can be accurately determined.

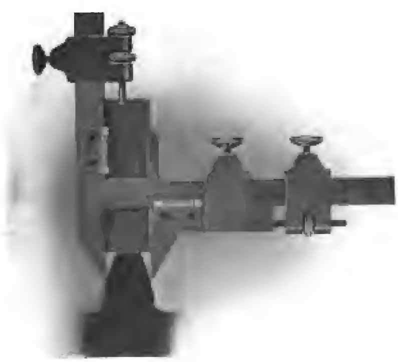


Fig. 61

Another tool, Vernier Caliper, No. 573, by use of which the bottom diameter of the teeth may be accurately measured to determine the depth of grooves, is shown in Fig. 62.

The depth of grooves may be ascertained when there are an even number of teeth by cutting two grooves opposite each other on the circumference of the blank and calipering the diameter from the bottom of the grooves, then computing the depth. When the number of .teeth is uneven cut one groove and caliper the diameter from the bottom of the groove to the opposite side of the blank. In this last case be sure that the blank is of the correct diameter and runs true, otherwise the measurement will not be correct, unless allowance is made for these points.

Indexing. Indexing gear blanks is essentially the same as indexing any other work, and the instructions in Chapter IV are complete on

Fig. 62

this subject; therefore it is unnecessary to make any additional remarks here upon this point.

Cutting Two or More Gears Simultaneously. If the holes in the blanks are straight, and the hubs do not project beyond the face, a number of blanks may be fastened together on a gang arbor and several gears cut at a time. Care should be taken, however, if this is done, to see that the sides of the blanks are exactly parallel, otherwise when the arbor nut is clamped, the blanks will spring the arbor, causing it to run out and making it impossible to produce accurate gears.

Cutting Bevel Gears. The teeth of bevel gears constantly change in pitch from their large to small end, and for this reason it is impossible to cut gears whose tooth curves are theoretically correct, with rotary cutters having fixed curves, such as those used for cutting these gears in a milling machine. The cutter employed must be of a curve that will make the correct form at the large end of the tooth, hence it will necessarily leave the curve too straight at the small end. It is, therefore, the practice to cut the teeth as nearly correct as possible,

and then finish the gears by hand, filing the small ends of the teeth to get the correct curve.

Pitch of Bevel Gear. The pitch of a bevel gear is always considered as that at the largest end of the teeth.

Data Required to Cut Bevel Gears with Rotary Cutter. Pitch and number of teeth in each gear.

The whole depth of tooth spaces at both large and small ends of teeth.

The thickness of teeth at both ends.

The height of teeth above the pitch line at both ends.

The cutting angle; the angle to set spiral head on milling machine, and the proper cutter or cutters.

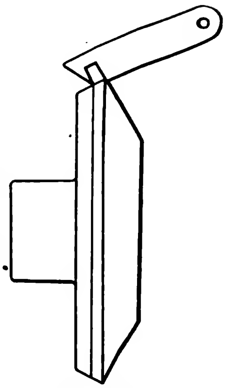


Fig. 63

Scratch Depth Line on Blank. Before placing the blank on machine, measure the length of face, angles and outside diameter of blank, and, if all dimensions are correct, place the blank on the arbor and fasten it securely in place; then scratch the whole depth of space at large end with a depth of gear tooth gauge similar to that shown in Fig. 63.

Selection of Cutter for Bevel Gears. The length of teeth or face on bevel gears is not ordinarily more than one-third the apex distance, Ab, Fig. 64, and cutters usually carried in stock are suitable for this face. If the face is longer than one-third the apex distance, special thin cutters must be made.

Rule for Selecting Cutter. Measure the back cone radius a b for the gear, or b c for the pinion. This is equal to the radius of a spur gear, the number of teeth in which would determine the cutter to use. Hence twice a b times the diametral pitch equals the number of teeth for which the cutter should be selected for the gear. Looking in the list given on page 147, the proper number for the cutter can be found.

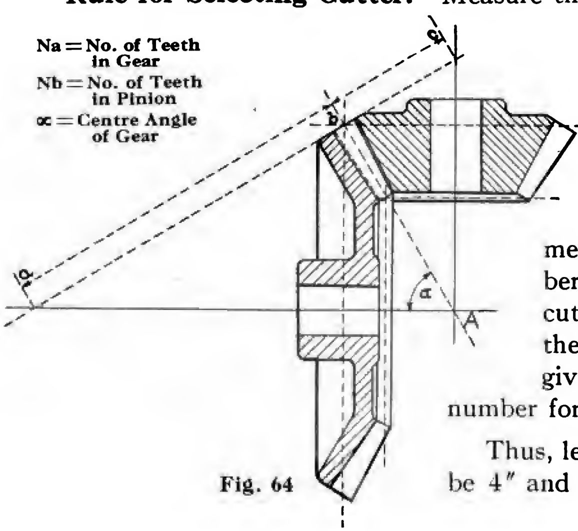


Fig. 64

Thus, let the back cone radius a b be 4″ and the diametral pitch be 8.

Twice four is 8, and 8 x 8 is 64, from which it can be seen that the cutter must be of Shape No. 2, as 64 is between 55 and 134, the range covered by a No. 2 cutter.

The number of teeth for which the cutter should be selected can also be found by the following formula:

$$Tan.\ \alpha = \frac{Na}{Nb}$$

$$\text{No. of teeth to select cutter for gear} = \frac{Na}{Cos.\ \alpha}$$

$$\text{No. of teeth to select cutter for pinion} = \frac{Nb}{Sin.\ \alpha}$$

If the gears are mitres or are alike, only one cutter is needed; if one gear is larger than the other, two may be needed.

Setting Cutter out of Centre. As the cutter cannot be any thicker than the width of space at small end of teeth, it is necessary to set it out of centre and rotate the blank to make the spaces of the right width at the large end of the teeth.

The amount to set cutter out of centre can be calculated with the table on page 324 and the following formula:

$$\text{Set-over} = \frac{Tc}{2} - \frac{\text{factor from table}}{P}$$

P = diametral pitch of gear to be cut.

Tc = thickness of cutter used, measured at pitch line.

Given as a rule, this would read: Find the factor in the table corresponding to the number of the cutter used and to the ratio of apex distance to width of face; divide this factor by the diametral pitch and subtract the quotient from half of the thickness of the cutter at the pitch line.

As an illustration of the use of this table in obtaining the set-over, take the following example: A bevel gear of 24 teeth, 6 pitch, 30 degrees pitch cone angle and $1\frac{1}{4}''$ face. These dimensions call for a No. 4 cutter and an apex distance of 4 inches.

In order to get the factor from the table, the ratio of apex distance with length of face must be known. This ratio is $\frac{4}{1.25} = \frac{3.2}{1}$, or about $\frac{3\frac{1}{4}}{1}$. The factor in the table for this ratio with a No. 4 cutter is 0.280. Next, measure the cutter at the pitch line. To do this, refer to the regular "Table of Tooth Parts" on pages 321 and 322, and get the depth of space below pitch line $s + f$. This depth of space below pitch line can also be found by dividing 1.157 by the diametral

pitch. In the case of 6 pitch $s + f = 0.1928$ inch. The thickness of the cutter at the pitch line is then found to be 0.1745 inch. This dimension will vary with different cutters, and will vary in the same cutter as it is ground away, since formed bevel gear cutters are commonly provided with side relief. Substituting these values in the formula, the following result is obtained:

Set-over $= \dfrac{0.1745}{2} - \dfrac{0.280}{6} = 0.0406$ inch, which is the required dimension.

After selecting a cutter and determining how much to set it out of centre, proceed as follows:

Set the cutter central with the spiral head or universal index head spindle, as the machine may be equipped.

Set the head to the proper cutting angle.

Set the index head for the number of teeth to be cut, placing the sector on the straight row of holes that are numbered to start with.

Set the dial on the cross feed screw to the zero line.

Scratch the depth of both the large and small end of the tooth to be cut in the blank.

Index and cut two or three grooves or centre cuts to conform to the lines in depth.

Set the cutter out of centre the trial distance, according to the formula on the previous page, by moving the saddle and noting adjustment on the cross feed screw dial.

Rotate the gear in the opposite direction from that in which the table is moved off centre (Fig. 65), until the side of the cutter nearest the centre line of the gear will cut the entire surfaces of the approaching sides of the teeth.

After making one or more cuts in accordance with this setting, move the table the same distance on the opposite side of the centre and rotate the gear in the opposite direction from that in which the table is moved until the cutter just touches the side of a tooth at the small end and cuts the entire surface of this side the same as the other.

Cut one or more spaces and measure the teeth at both large and small ends, either with a gear tooth vernier or with gauges made from thin pieces of metal and having a slot cut to give the correct depth and width at the pitch line.

If the teeth at the large end are too thick when the small end is correct, the amount to set the table out of centre must be increased. On the other hand, if the small end is too thick when the large end is

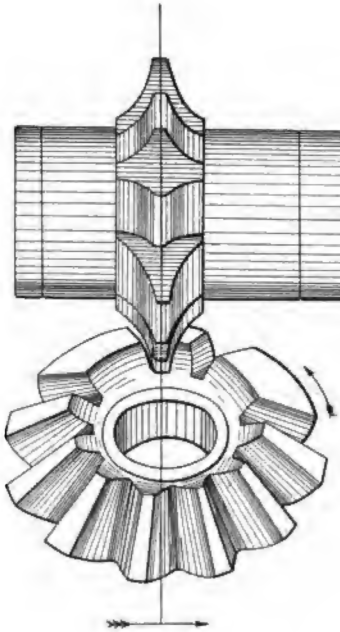


Fig. 65

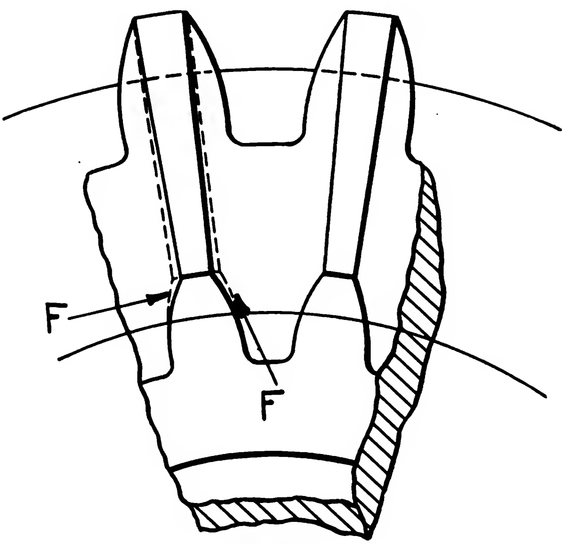


Fig. 66

correct, the amount the table is set out of centre is too great. In either case, the settings must be changed, and the operations of cutting repeated, remembering that the blank must be rotated and the table moved the same amount each side of centre, otherwise the teeth will not be central. It is well to bear in mind that too much out of centre leaves the small end proportionately too thick, and too little out of centre leaves the small end too thin.

The adjustment of the cutter and the rotating of the blank are shown in Fig. 65, which shows the setting, so that the right side of cutter will trim the left side of tooth and widen the large end of the space. The table has been moved to the right and the blank brought to the position shown, by rotating it in the direction of the arrow; the first out of centre cut was taken when the cutter was set on the other side of the centre.

After determining the proper amount to set cutter out of centre, the teeth can be finished, without making a central cut, by cutting round the blank with the cutter set out of centre, first on one side and then on the other.

To prevent the teeth being too thin at either end, it is important, after cutting once around the blank with cutter out of centre, to give careful attention to the rotative adjustment of the gear blank, when setting the cutter for trimming the opposite sides of the teeth. If by measurement, both ends are a little too thick, but proportionately right, rotate the gear blank and make trial cuts until one tooth is of the correct thickness at both ends. The cutting can then be continued until the gear is finished. Teeth of incorrect thickness may be more objectionable than a slight variation in depth.

The finished spaces, or teeth, as already mentioned, are of the correct form at the larger ends, and the teeth are of the correct thickness their entire length, but the tops of the teeth at the small ends are not rounded over enough. It is, therefore, generally necessary to file the faces of the teeth slightly above the pitch line at the small ends, as indicated by the dotted lines F F, Fig. 66. In filing the teeth, they should not be reduced any in thickness at or below the pitch line.

When cutting cast iron gears coarser than five diametral pitch, it is best to make one central cut entirely around the blank before attempting to find the correct setting of the cutter or rotation of the blank for correct thickness of teeth; and it is generally advantageous to take a central cut on nearly all bevel gears of steel.

Cutting Spiral Gears. In Chapter IV, we have gone into the subject of cutting spirals thoroughly, and, inasmuch as spiral gears are essentially cylinders having a succession of spiral grooves evenly spaced on their periphery, many of the points we have treated apply equally well to cutting them.

An important point in cutting these gears is the selection of the proper cutters to use. It is impossible to give in concise form any set of rules for doing this that will be readily understood, and anyone who desires to cut spiral gears, should make a far more complete study of the subject of spiral gearing than we can possibly give in this book. It is treated upon in our "Practical Treatise on Gearing," and "Formulas in Gearing," both of which books are extremely useful to the practical workman.

One point that it is well to remember is that in calculating spirals, the angle should be figured as that at the pitch line of the teeth, and not that on the surface or periphery of a gear.

Spirals of any angle to 45° can be cut in all of our universal milling machines with the cutter mounted in the regular way, and the swivel table swung to the proper angle, while those of an angle up to 53° with the axis, can be cut in some of our universal machines. If, however, the required angle is greater than that to which the table can be set, a vertical spindle milling attachment is required, and the adjustment for the cutting angle is then done with the attachment.

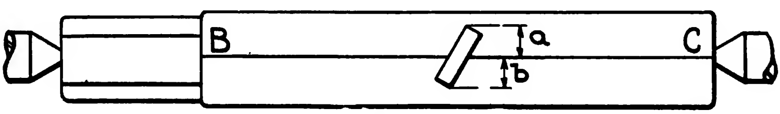


Fig. 67

To Set Cutter Central. It is essential that the cutter be set central with the work centres, and it may be done as follows: First, set the table, or attachment, in case the latter is used, to the correct cutting angle. Take a trial piece, Fig. 67, which is simply a cylindrical piece with centre holes in the ends, and mount it on the work centres, dogging it to the spiral head spindle. Draw, or scratch the line B C on the side of the arbor at the exact height of the work centres, and then revolve the arbor one-quarter of a turn by means of the index crank; that is, bring the mark B C exactly on the top of the piece. Now, start the machine and raise the knee until a gash is cut on the top of the piece. This gash shows the position of the cutter, and if a and

b are equal, the cutter is centred with the trial piece, which will, of course, bring it central with the work.

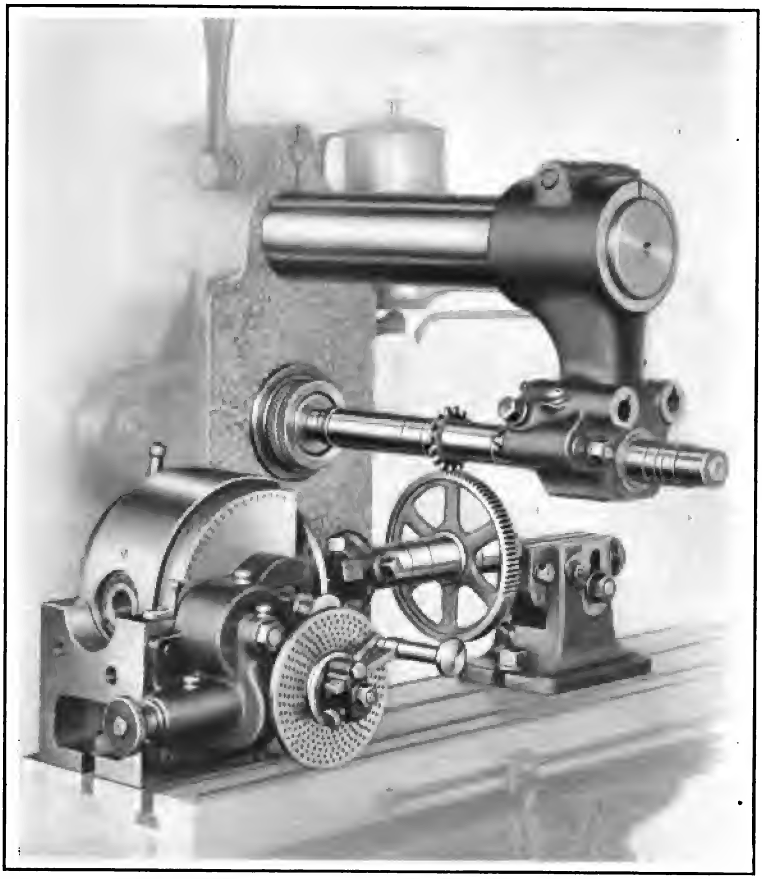
The same method is employed when using a vertical spindle milling attachment, except the scratched line is left at the side of the piece where it is at the exact height of the centres. The gash is then cut and examined as described above.

Test Settings and Index Gears. Before cutting a blank, it is well to raise the knee until the cutter will just make a slight trace on the work to see if the lead obtained by the change gears is correct. If the material in the gear blank is expensive, it is sometimes advisable to make a cast iron blank to experiment with before cutting into the expensive material.

Fastening Blanks. Spiral gears are more liable to slip in cutting than spur gears. Small blanks may be dogged to the spindle, but the dog must be far enough from the blank so that it will not interfere with the cutter. For blanks that are more than three or four inches in diameter, it is better to use a taper shank arbor held directly in the spindle; and for still heavier work, the arbor may be drawn into the spindle with a threaded rod.

Cutting Teeth. In cutting the teeth, either the cutter should be stopped after cutting each groove and positioned so that the teeth will not scrape the sides and bottom of the groove, the table being returned by hand; or the knee should be dropped so that cutter will clear the groove just cut, and then run the table back to the starting point. Most mechanics prefer to stop the machine, for in dropping the knee, there is more liability of error, as the depth of cut has to be set for each groove, and this also takes more time than it does to stop the machine.

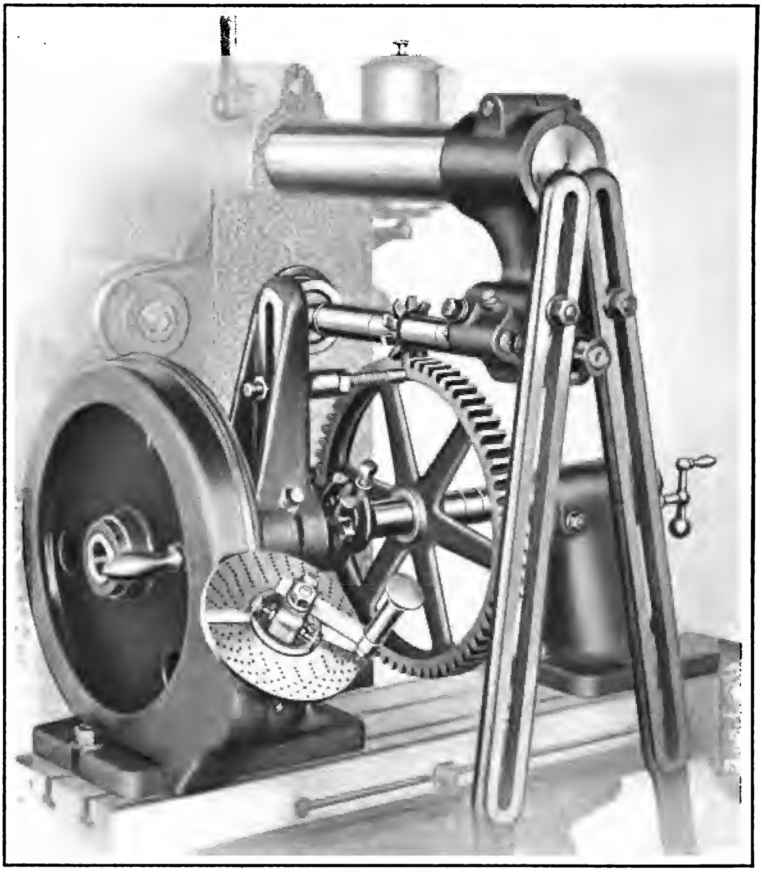
The remaining pages of this chapter are devoted to illustrations and descriptive data of gear cutting and similar operations on milling machines. These operations show how different gear cutting jobs can be set up, and are given simply as suggestions for those not familiar with this class of work.



Cutting a Spur Gear, Using the Spiral Head

Cutting a spur gear on a milling machine is a comparatively simple operation, as can be seen from the illustration. No special rigging whatsoever is required. The blank in this case is fastened on an ordinary lathe arbor mounted on the centres and dogged to the spiral head spindle.

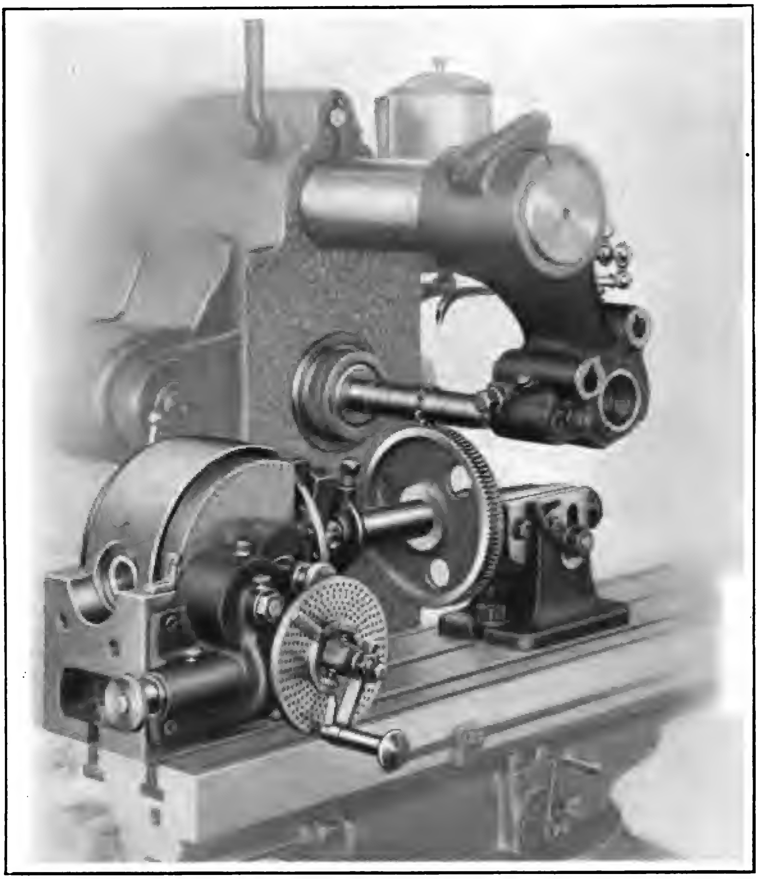
In commercial manufacturing, gears such as that shown would be produced in quantities on automatic gear cutting machines, but where only an occasional gear is wanted, such as in replacing a broken one, it is advantageous to cut it on a milling machine. A new gear for a machine can usually be secured in this manner far quicker than it can be ordered and delivered.



Cutting a Large Spur Gear, Using Gear Cutting Attachment

This operation shows the use of the gear cutting attachment described in Chapter V. The gear being cut is too large to be accommodated by the spiral head centres without using raising blocks, and then the results are not as satisfactory as can be gained by using this attachment.

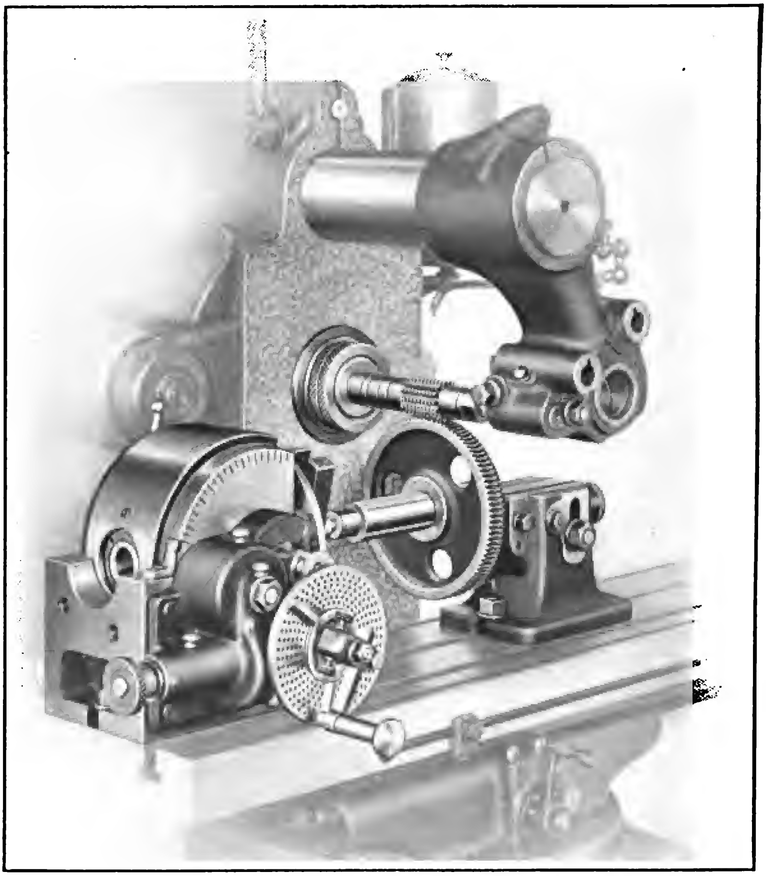
The gear is supported similarly to that on the opposite page. The advantage of a rim rest is illustrated, and it should also be noted that where the cut is as heavy as that shown, it is advisable to use the arm braces to give added stiffness to the cutter arbor. The table is fed from left to right, or so that the cut is against the rim rest.



Gashing Teeth in Worm Wheel

Finishing a worm wheel on a milling machine requires two separate operations. First, the operation of gashing the teeth, shown above, is performed; and then the teeth are hobbed, as shown in the illustration on page 162.

In gashing the teeth, the blank is dogged to the spiral head spindle, and the swivel table is swung to the required angle. The vertical feed is used and the teeth are indexed the same as in cutting a spur gear. Most of the stock is removed in gashing, only enough being left to allow the hob to take a light finishing cut.



Hobbing Teeth in Worm Wheel

The work is set up practically the same as in the operation of gashing the teeth, only the dog on the arbor is removed and the swivel table is set at zero. The worm wheel revolves freely on the centres, being rotated by the hob.

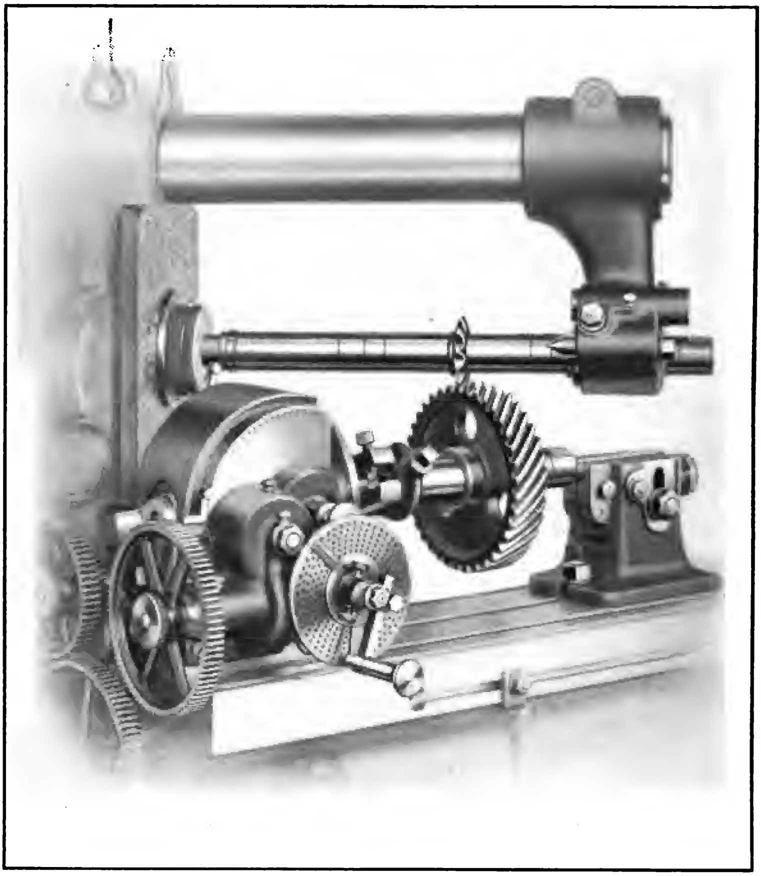
The wheel can be hobbed to the right depth by using a steel rule at the back of the knee to measure a distance equal to the centre distance of the worm and wheel from a line marked "Centre," on the vertical slide to the top of the knee. This line on the vertical slide indicates the position of the top of the knee when the index centres are at the same height as the centre of the machine spindle.

Cutting Teeth in Bevel Gear

The illustration on this page shows a milling machine set up for cutting the teeth of a bevel gear.

The gear is held in place by a split bushing that is expanded in the hole. The spiral head is elevated to the proper cutting angle and the table is fed longitudinally from left to right.

In setting off centre to trim the sides of the teeth to the proper thickness, the table is adjusted the required amount on the knee and then the blank is rotated by means of the index crank, as previously explained.

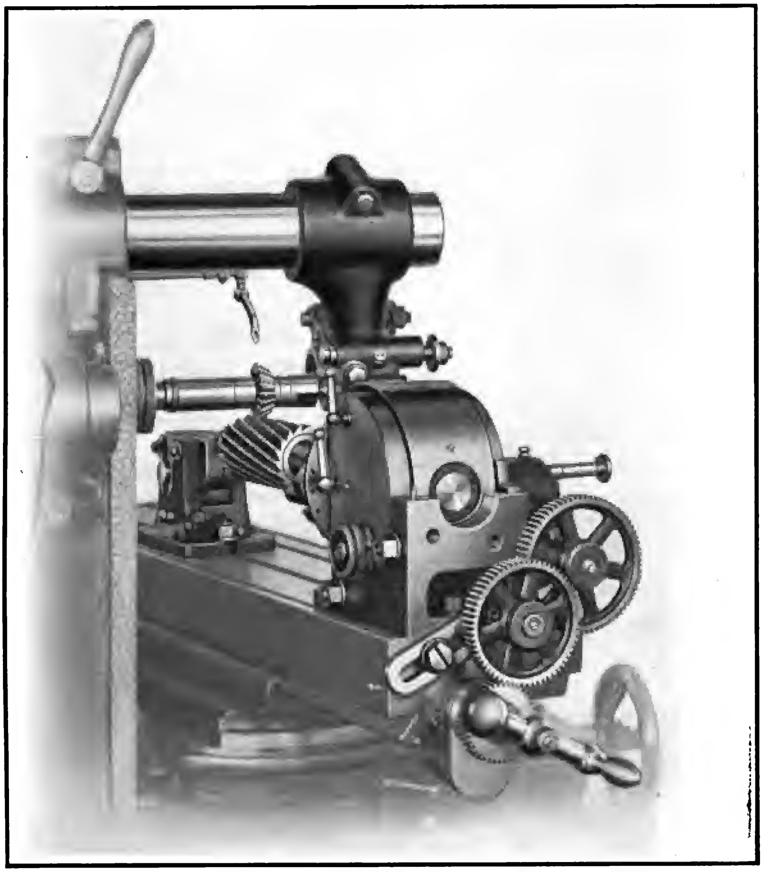


Cutting Teeth in Spiral Gear

The machine is shown, in the illustration above, set in position to cut a left-hand spiral gear of 45° angle.

The gear is mounted in the same manner as in several previous operations, but instead of remaining stationary as the table advances, it is rotated by means of the required change gears to give the correct lead to the teeth. The table is fed longitudinally from left to right.

A right-hand spiral gear of the same angle may be cut in the same manner by setting the table to 45° the other side of zero and leaving out the intermediate or reverse gear.

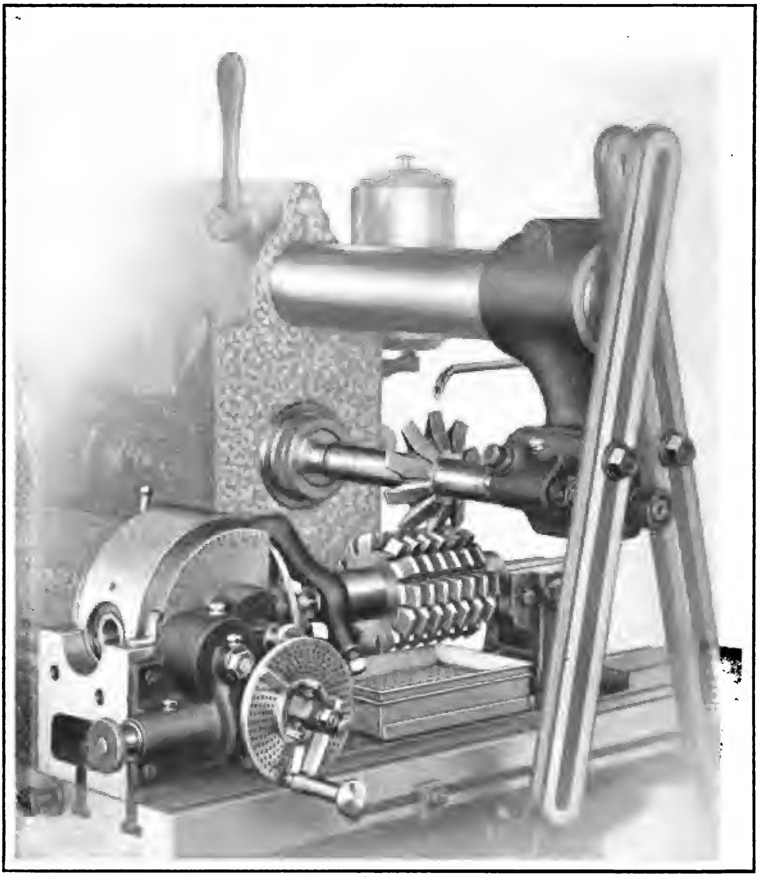


Cutting Spiral Teeth in Milling Cutter

This operation shows the arrangement for cutting teeth in a right-hand spiral milling cutter.

The work is 6 inches long and 3 inches in diameter, and an angular cutter 3 inches in diameter is employed. An angle of $11\frac{1}{4}°$ is desired, and the saddle is accordingly set to that angle and the head is geared to give a lead of 48″.

The work is mounted on an arbor that is dogged to the spiral head spindle, and care is taken that there is no lost motion between the spindle and work.

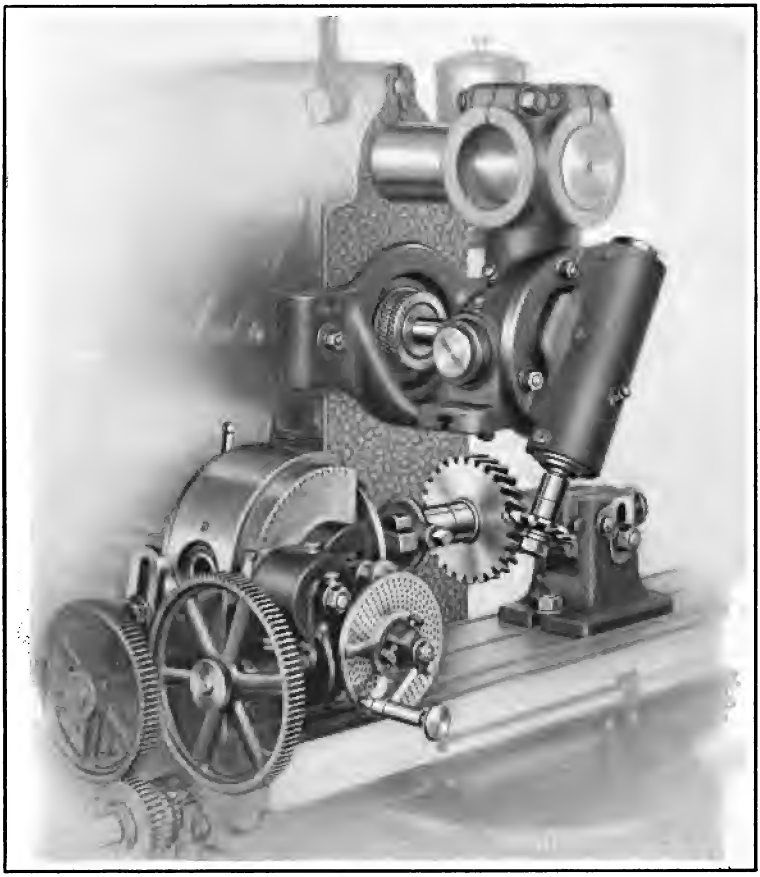


Gashing a Hob

While this is not strictly a gear cutting operation, it is set up and performed in practically the same manner, the principal difference being in the shape of cutter used. Many hobs are gashed spirally, and this is done in a similar way to cutting the teeth in a spiral gear.

In this operation, the cut is heavy and it is advisable to use arm braces, so that a coarser feed can be employed and the work done more quickly.

The table is fed longitudinally from left to right. Oil is used on the cutter and is collected and strained in the pan below the work. An oil pump equipment can be used to good advantage on such jobs.

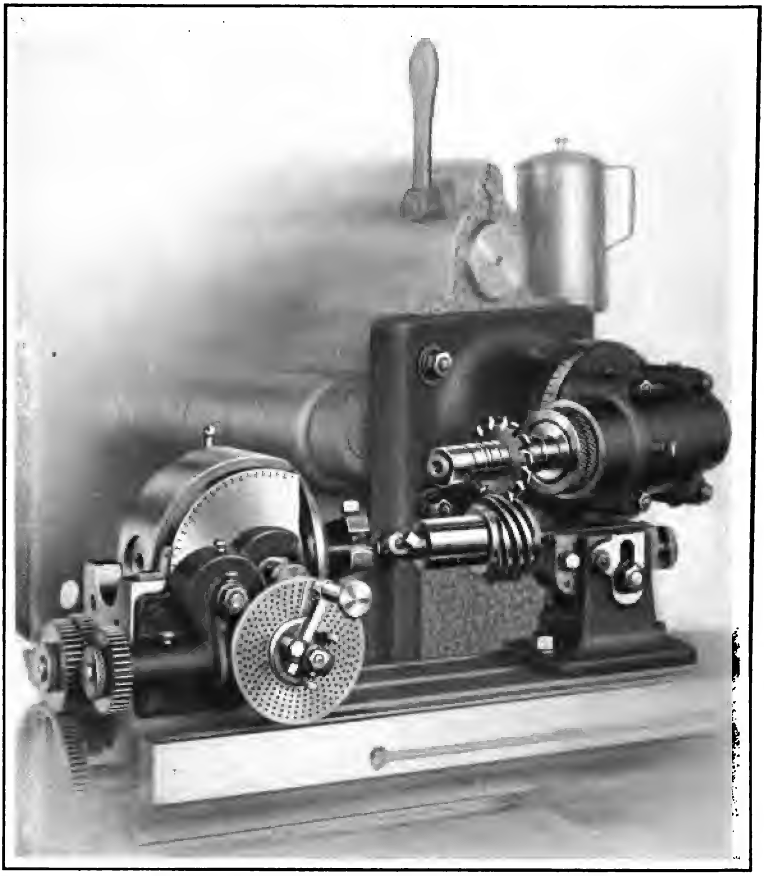


Cutting Teeth in Spiral Gear, Using Compound Vertical Spindle Milling Attachment

This operation shows the use of a compound vertical spindle milling attachment in cutting a spiral gear.

It will be noticed that where this attachment is used, the swivel table is set at zero and the angle of the spiral obtained by swinging the head of the attachment. The cutting is also done on the side, instead of the top of the gear.

In cutting left-hand spirals, the cutter would be at the back of the blank, the head of the attachment swung to the other side of zero, and an intermediate gear would be introduced in the train to reverse the direction of rotation.



Cutting a Short Lead Spiral Gear, Using a Vertical Spindle Milling Attachment

When the table cannot be swung to the required angle, a vertical spindle attachment may be used. The attachment is swung 90° up from zero, and the required angle of the spiral is then obtained by the swivel table.

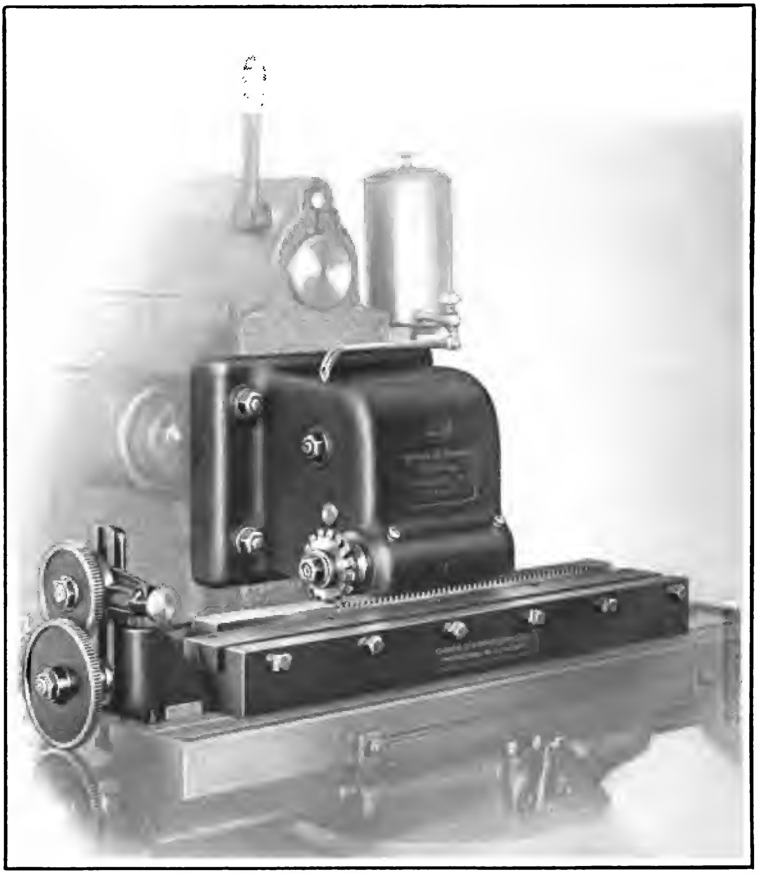
Where the lead is as short as that above, it is better to employ the special attachment shown in Chapter V, for the ratio of gearing of the spiral head is such that severe stresses are brought to bear upon it in feeding the work. If, however, the job is set up as above, it is necessary to feed the work by hand.

Milling Rack Teeth in Cylindrical Shaft

Sometimes it is required to mill a few rack teeth in a cylindrical shaft or plunger, and where a rack cutting attachment is at hand, this can be readily done. If one is not convenient, however, the work can be done in the manner shown above.

The shaft is supported on a parallel and clamped in a vise, and the teeth are indexed by means of the graduated dial on the cross feed screw.

Before indexing, care should be taken to remove backlash from the screw.

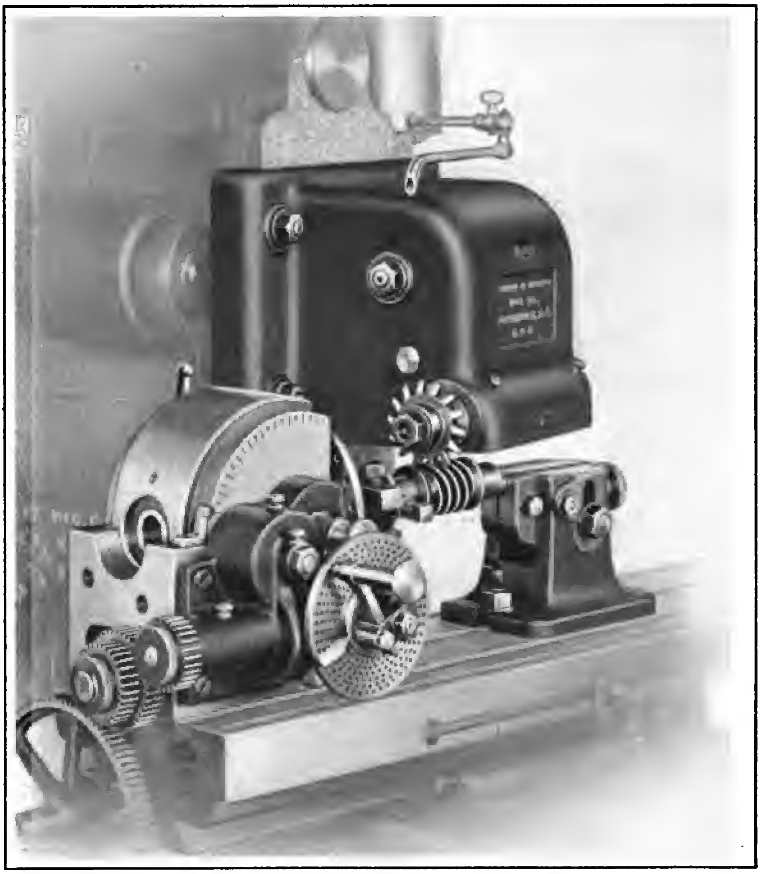


Cutting Teeth in Rack, Using Rack Cutting and Indexing Attachments

The method of cutting a steel rack, using the rack cutting and indexing attachments described in Chapter V, is clearly shown in this illustration.

The rack is fastened in the vise of the attachment, and the teeth are indexed by the indexing attachment.

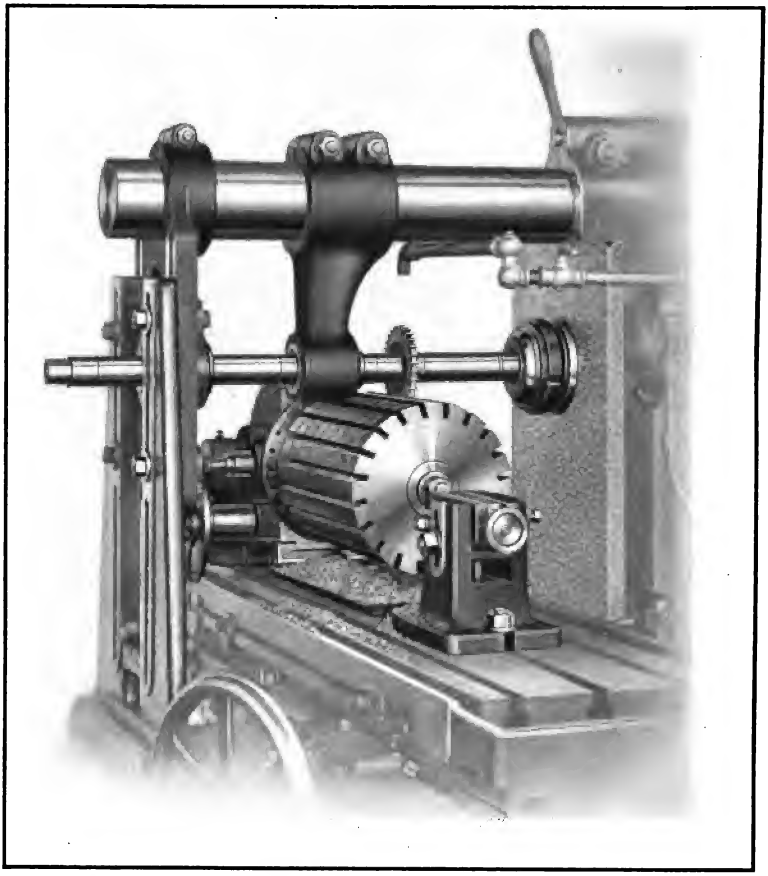
The automatic transverse table feed is used and the direction of cut is from the back of the rack toward the front, that is, against the direction in which the cutter rotates. Oil is used as a lubricant.



Cutting a Worm Thread, Using Rack Cutting Attachment

Another use of the rack cutting attachment on a universal milling machine is illustrated in this operation. It is especially serviceable for cutting short lead spiral gears, when the angle is such that they cannot be cut on the milling machine in the usual way. An advantage of the rack cutting attachment over the vertical spindle milling attachment for this purpose is that work of smaller diameter can be accommodated, or a smaller cutter can be used.

The cutting is done on the top of the work, and oil may be led to the cutter from the can shown.

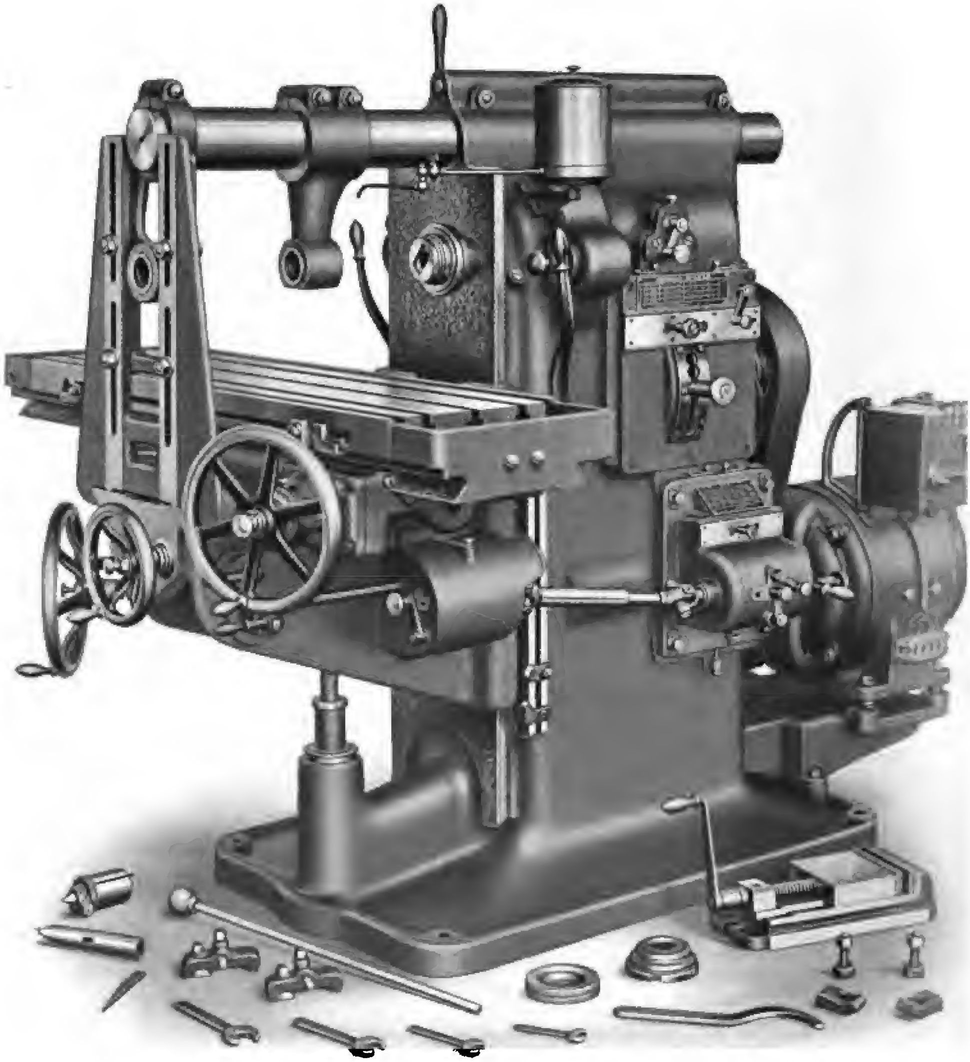


Cutting Blade Grooves in Bodies of Inserted Tooth Cutters

Nine of these steel cutter bodies are placed together on an arbor and clamped solidly by a nut at the end. The arbor is then driven into the spiral head spindle and the foot-stock is put in place. To give the proper rake to the front of the blades, the saddle is set so that the cutter does not come directly over the spiral head and foot-stock centres. As the number of grooves cut is 20, indexing can be conveniently accomplished with any index plate.

A side milling cutter 5 inches in diameter and $\frac{7}{16}''$ wide is used, and the grooves are cut to a depth of $\frac{7}{8}''$.

Section of Milling Machine Department in Our Works, Showing Erecting of Machines in Large Lots



Constant Speed Drive Plain Milling Machine fitted with Motor Drive

CHAPTER IX

Milling Operations—Cam Cutting, Graduating, and Miscellaneous Operations

Cam Cutting. Face, peripheral and cylindrical cams of all ordinary sizes can be cut upon a milling machine, and a far more satisfactory job can be obtained than is possible by drilling around the outline on a cam blank, breaking it off and then milling or filing to a line.

When it is required to cut several cams of the same outline at frequent intervals, it is an advantage to add the cam cutting attachment, illustrated and described in Chapter V, to the equipment of the machine. The formers that are required to produce the different cams can be preserved, and it is then only a matter of a few minutes' time to set up the machine to cut any number of cams for which a former is at hand.

Another method that is often followed, in cutting peripheral cams, especially those for use on automatic screw machines, is that of using the spiral head and a vertical spindle milling attachment. Illustrations of this are shown on pages 185 and 186. The spiral head is geared to the table feed screw, the same as in cutting ordinary spirals, and the cam blank is fastened to the end of the index spindle. An end mill is used in the vertical spindle milling attachment, which is set in each case to mill the periphery of the cam at right angles to its sides, or, in other words, the axes of the spiral head spindle and attachment spindle must always be parallel to mill cams according to this method. The cutting is done by the teeth on the periphery of the end mill. The principle of this method is as follows: Suppose the spiral head is elevated to 90°, or at exact right angles to the surface of the table (See Fig. 68), and is geared for any given lead. It is then apparent that, as the table advances and the blank is turned, the distance between the axes of the index spindle and attachment spindle becomes less. In other words, the cut becomes deeper and the radius of the cam is shortened, producing a spiral lobe, the lead of which is the same as that for which the machine is geared.

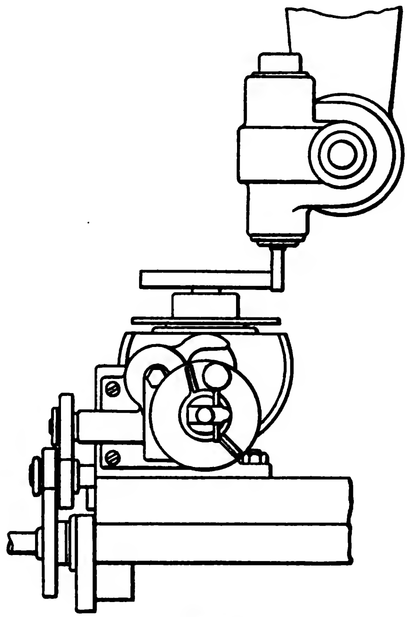


Fig. 68

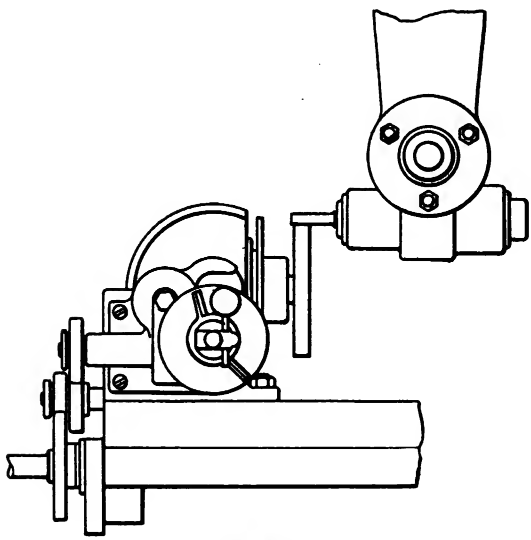


Fig. 69

Now, suppose the same gearing is retained and the spiral head is set at zero, or parallel to the surface of the table (See Fig. 69). It is apparent, also, that the axes of the index spindle and attachment spindle are parallel to one another. Therefore, as the table advances, and the blank is turned, the distance between the axes of the index spindle and attachment spindle remains the same. As a result, the periphery of the blank, if milled, is concentric or the lead is 0.

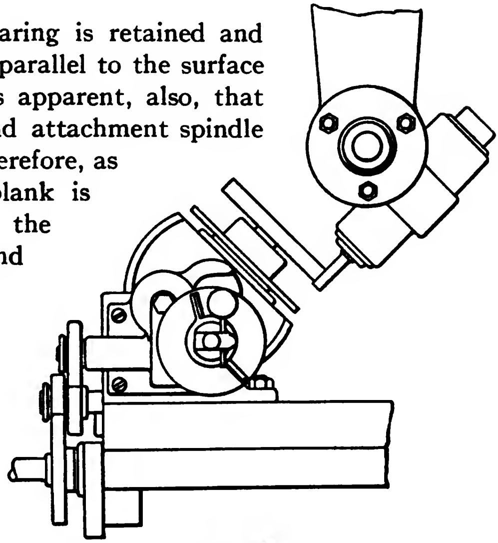


Fig. 70

If, then, the spiral head is elevated to any angle between zero and 90 (See Fig. 70), the amount of lead given to the cam will be between that for which the machine is geared and 0. Hence it is clear that a very large range of different leads can be obtained with one set of change gears, and the problem of milling the lobes of a cam is reduced to a question of finding the angle at which to set the head to obtain any given lead.

In order to illustrate the method of obtaining the correct angle, drawings of two cams to be milled, and data connected with same, are given in Figs. 71 and 72.

It is first necessary to know the lead of the lobes of a cam, that is, the amount of rise of each lobe if continued the full circumference of the cam. This can be obtained from the drawings as follows: For cams where the face is divided into hundredths, as those shown: multiply 100 by the rise of the lobe in inches and divide by the number of hundredths of circumference occupied by the lobe. For cams that are figured in degrees of circumference: multiply 360 by the rise of the lobe in inches and divide by the number of degrees of circumference occupied by the lobe. Taking Fig. 71 for example, we have a cam of one lobe which extends through 91 hundredths of the circumference, and has a rise .178″. $\frac{100 \times .178''}{91} = .1956$ lead of lobe, or .196″, which is near enough for all practical purposes.

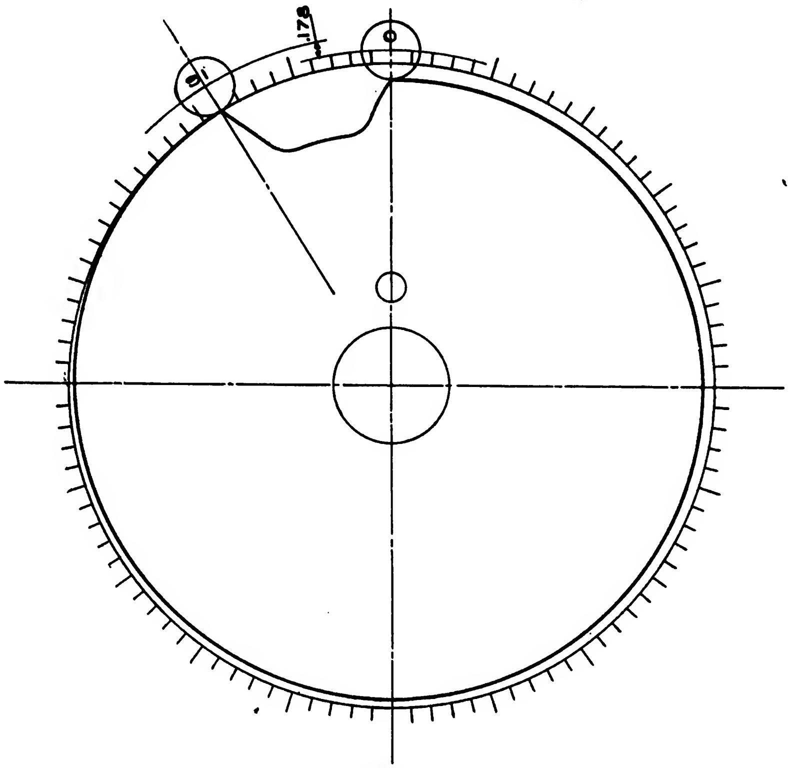


Fig. 71

As a .196″ lead is much less than .67″, which is the shortest lead* regularly obtainable on the milling machine (See Table of Leads, pages 227 to 245), the change gears that will give a lead of .67″ may be used, and then the angle of the head can be adjusted so that a lead of .196″ will be obtained on the cam lobe with these change gears. The rule for this is:

Divide the given lead of the cam lobe by a lead obtainable on the machine, and the result is the sine of the angle at which to set the head.

Continuing the calculation for the lobe of the cam in Fig. 71, we therefore have: $\frac{.196''}{.67} = .29253$

Hence, .29253 is the sine of the correct angle. Turning to the Table of Sines and Cosines on pages 298 and 306, we find that .29253 is very near

* By the use of the short lead spiral attachment, illustrated and described in Chapter V, much shorter leads than .67″ are obtainable.

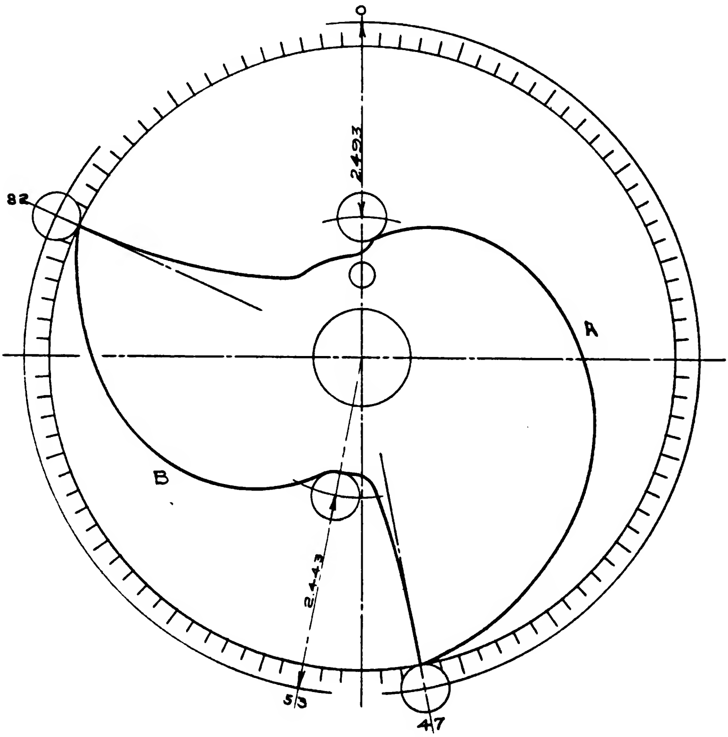


Fig. 72

.29265, which is the sine of an angle of 17° and 1′. As the spiral head is not graduated closer than quarter degrees, it will be satisfactory to elevate the head just a hair over 17°; then, with the gearing for a lead of .67″, a lead of .196″ will be obtained.

The minute errors between the actual lead .1956″ and .196″, and in the sines and angles of this calculation can be safely ignored, as it is not possible in practice to work very much closer than we have outlined.

The portion of the periphery of the cam from 91 hundredths to zero, represents a clearance of the cutting tool prior to the beginning of the throw. It is usually milled to a line, or drilled, broken out, and filed.

In Fig. 72, we have a cam with two lobes, one, A, having a rise of 2.493″ in 47 hundredths, and the other, B, having a rise of 2.443″ in 29 hundredths. On cams such as this, where it is necessary to remove considerable stock, it is usually the practice to first outline

the approximate shape of the lobes on the blank and drill and break off the surplus stock.

Following the same method of figuring to find the lead of the lobes on this cam, we have: $\frac{100 \times 2.493''}{47} = 5.304''$ lead for lobe A, and $\frac{100 \times 2.443''}{29} = 8.424''$ lead for lobe B.

Where there are two or more lobes on a cam, the machine is geared for a lead slightly longer than the longest one required, which in this case is 8.424", then the other lobes are milled without changing the gears. Referring to the Table of Leads, we find a lead of 8.437", which is slightly larger than 8.424". This gearing is, therefore, accepted, and it is required to find the sine of the angle at which to set the head for lobe B.

$\frac{8.424}{8.437} = .99846$ sine of angle at which to set head. Looking at the Table of Sines and Cosines, .99846 is found to be the sine of an angle of 86° and 49'. The head is, therefore, set at a trifle over $86\frac{3}{4}$°.

When lobe B has been milled, the head is set for lobe A.

$\frac{5.304}{8.437} = .62865$ sine of an angle at which to set head. Referring again to the Table of Sines and Cosines, we find that .62865 is very near to .62864, which is the sine of an angle of 38° and 57'. The head is, therefore, set slightly under 39° for this lobe.

The other portions of the periphery of this cam are formed up either by filing to a line before the blank is put on the milling machine, or by milling to the line after the lobes have been formed.

Whenever possible, the job should be set up so that the end mill will cut on the lower side of the blank, as this brings the mill and table nearer together and makes the job more rigid. It also prevents chips from accumulating, and enables the operator to better see any lines that may be laid out on the face of the cam.

When the lead is over 2 inches the automatic feed can be used, but when the lead is less than 2 inches the job should be fed by hand, with the index crank, as shown on page 185.

By the use of the calculations just given, we have compiled tables on pages 246 to 297 that give a wide range of leads from 0 to 20" that can be obtained with the spiral head in the manner described. These tables will be found useful, as they give all data and settings without the necessity of figuring.

Graduating. Another use to which the milling machine may be put is that of graduating flat scales and verniers.* It is possible to obtain very accurate results, and when required, odd fractional divisions can be easily spaced.

This operation requires the use of the spiral head and a single pointed graduating tool which is held stationary in a fly cutter arbor, mounted directly in the spindle, or can be fastened to the spindle of a vertical milling or rack cutting attachment. The scale to be

This gear should be on the end of spiral head spindle

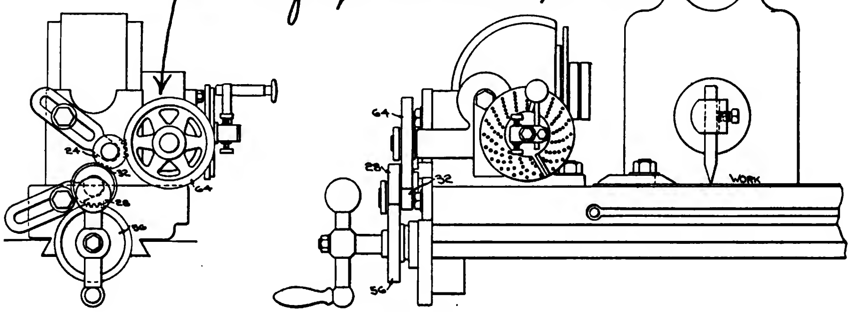


Fig. 73

graduated is clamped to the surface of the table parallel to the table T slots. No power is required for the operation, as the lines are cut by moving the table transversely under the point of the tool, and this can be easily done by hand. The spiral head spindle is equal-geared to the table feed screw as shown in Fig. 73, and indexing for the divisions required is accomplished by means of the index plates, the index crank being turned in the usual manner for each division.

It has already been explained that one turn of the index crank moves the spiral head spindle $\frac{1}{40}$ of a revolution, and if equal gearing is employed between this spindle and the table feed screw, the feed screw will likewise make $\frac{1}{40}$ of a complete revolution. The lead of the feed screw being .25″, it is apparent that one turn of the index crank will advance the table an amount equal to .25″ × $\frac{1}{40}$, or .00625″.

Suppose it is required to graduate a scale with lines .0218″ apart. Now, if one turn of the index crank moves the table a distance of

* A method of obtaining fine divisions on a circular plate is mentioned under Differential Indexing in Chapter IV.

.00625″, it will take more than one turn to move the table a distance of .0218″. Hence,

$$\frac{.02180}{.00625} = 3\frac{.00305}{.00625}$$

Taking the remainder, .00305″, and referring to the tables on pages 316 to 318, we find that it is very near .0030488, which is the distance the table will be moved by using the 41 hole circle in one of the index plates furnished and indexing 20 holes. The error between the actual remainder and the amount given in the table is so small that it can be safely ignored.

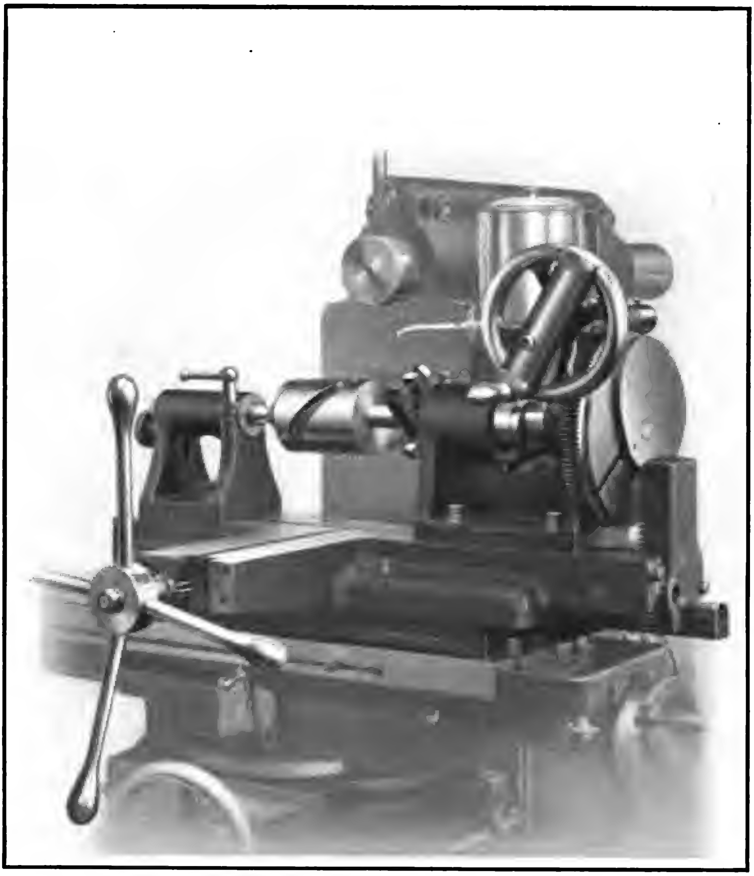
Therefore, to graduate a scale with divisions .0218 of an inch apart, an index plate having a 41 hole circle would be used and the crank would have to make three complete turns and then be advanced 20 holes in the 41 hole circle for each division.

It should be remembered in graduating that care must be exercised to prevent backlash between the index crank and table feed screw. To this end, the crank should always be turned in the same direction.

If required, the ratio of gearing between the spiral head spindle and the table feed screw can be changed, but this complicates the operation somewhat and should be resorted to only when it is impossible to get accurate enough results with the method described. Upon referring to the tables on pages 316 to 318 and noting the extreme fineness in divisions that it is possible to obtain, it is apparent that there is little occasion to change the ratio of gearing.

Accurate graduating can also be done by using scales and verniers such as illustrated and described in Chapter V.

Illustrations of cam cutting, and many miscellaneous milling operations will be found on the following pages, and a careful study of the cuts and descriptions may be of value to the reader.

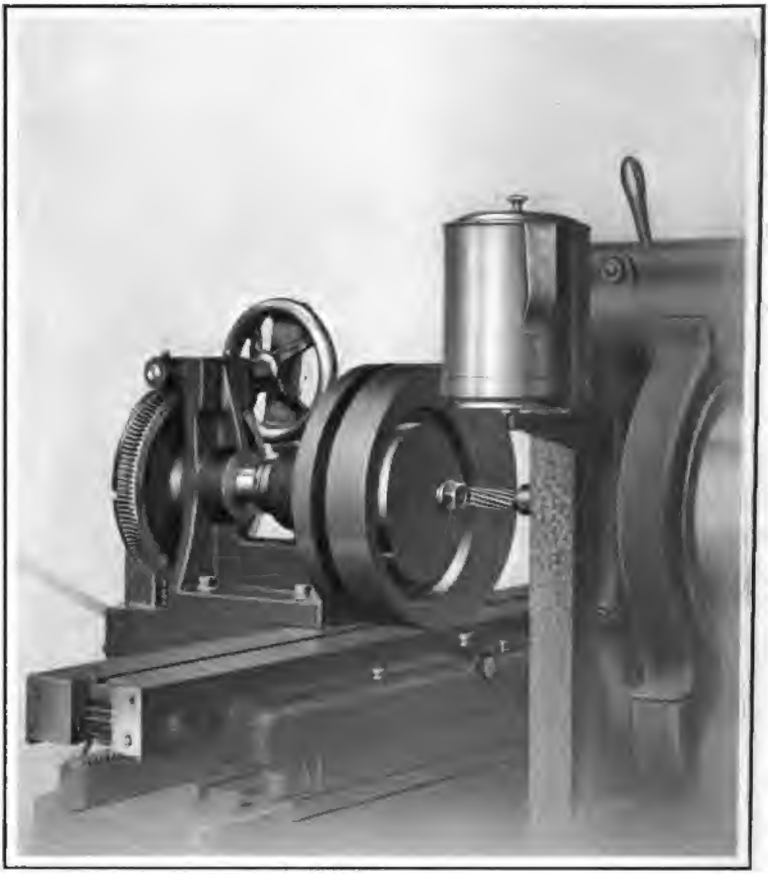


Cutting a Cylindrical Cam, Using Cam Cutting Attachment

For cutting a cylindrical cam, the head is bolted to the bed parallel to the table and the cam blank is supported on an arbor mounted on the attachment centres and dogged to the spindle. The table is raised to a point that brings the attachment centres at the same height as the axis of the spindle.

A spiral end mill is used for this operation and the necessary movement to feed the work is obtained from the attachment, the table remaining clamped in one position.

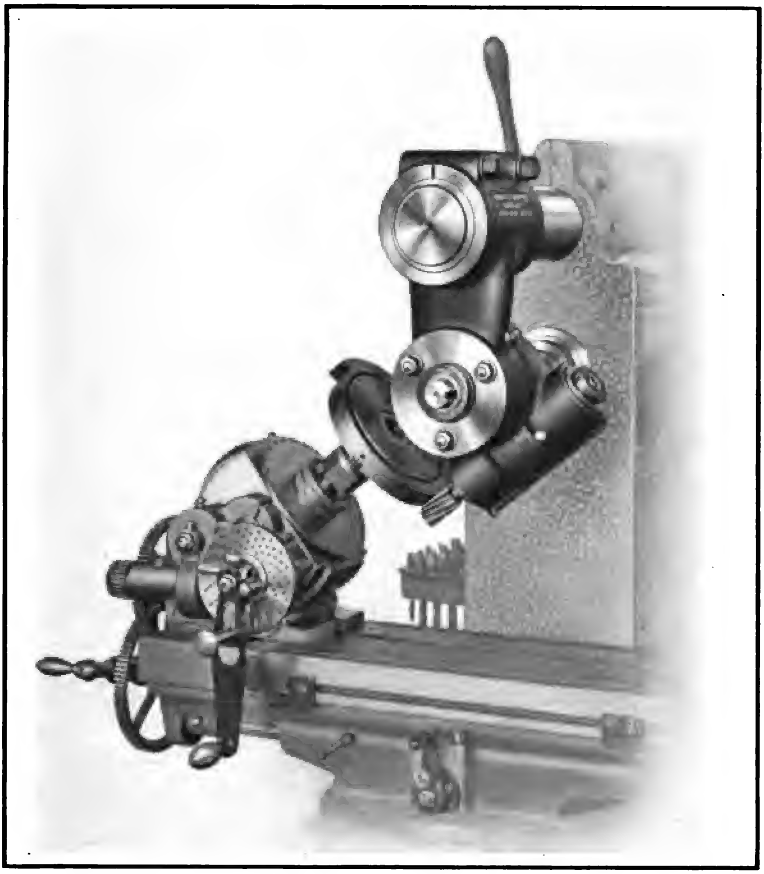
This view of the attachment shows very clearly the former on the outer end of the head.



Cutting a Face Cam, Using the Cam Cutting Attachment

In this operation the head of the attachment is bolted to the bed at right angles to the table and the cam blank is fastened to the attachment spindle by means of a bolt. A peripheral cam would be milled in the same manner. The necessary rotative movement is obtained by hand feed, and the longitudinal movement to give the proper lead and shape to the cam is produced by the cam former and the mechanism of the attachment, as described in Chapter V.

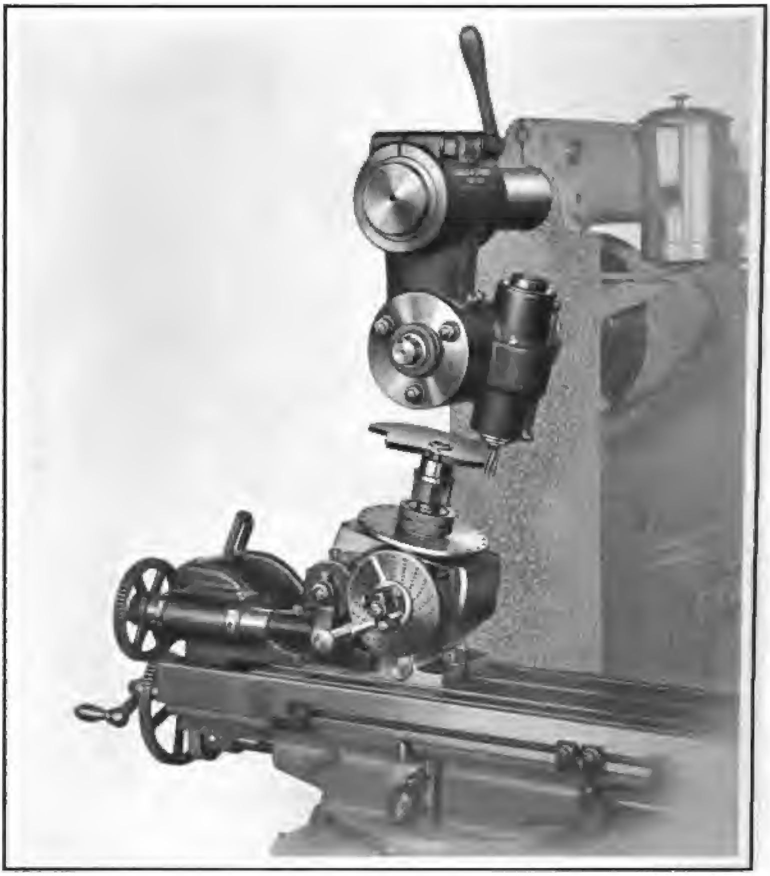
A spiral end mill is used. The machine table remains clamped in one position.



Milling a Cam, Using Spiral Head and Vertical Spindle Attachment

The cam blank is mounted on an expansion arbor inserted in the taper hole of the spiral head spindle.

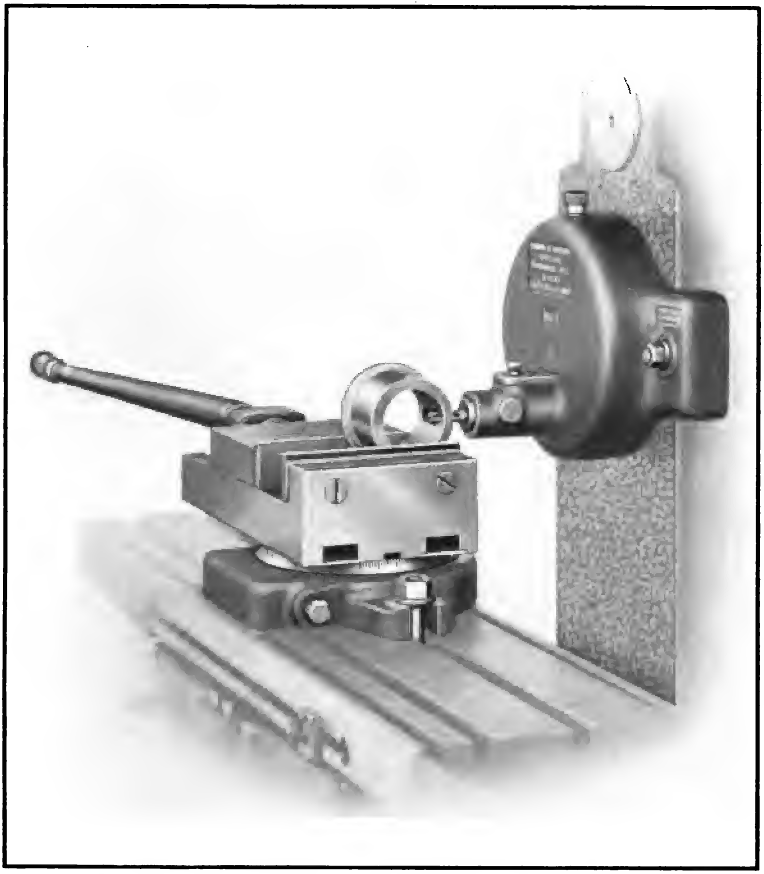
Suitable change gears are selected to give the approximate lead and the spiral head is elevated to obtain the exact lead; the vertical attachment is then set to bring the end mill parallel with the axis of the cam. Where such short leads as this are being milled, there is great stress brought upon the spiral head gearing in attempting to use the automatic feed. For this reason the extended crank is fastened over the regular index crank and the job is fed by hand.



Milling Screw Machine Cam, Showing Use of Extension for Spiral Head

This shows the milling of a cam of long leads where the blank must be cut well up to the axis in one place. It is impossible to bring the spiral head spindle and the vertical attachment spindle near enough together to accomplish this deep cut when the spiral head is located in its usual position at the end of the table. The extension for the spiral head is designed to overcome this difficulty, and by using it the spiral head is located some distance in from the end of the table.

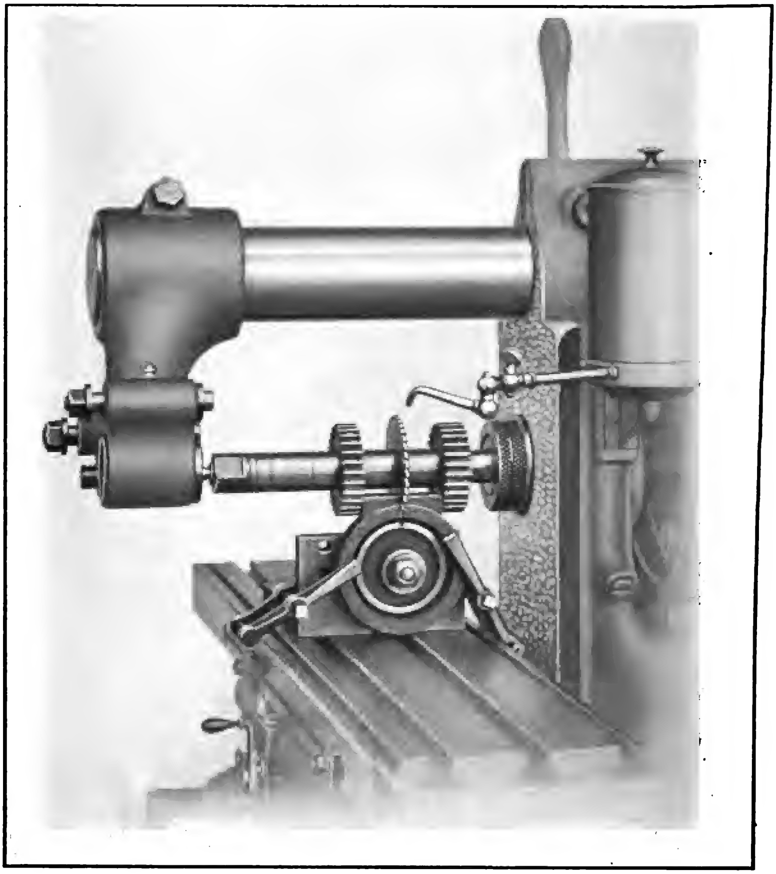
The cam in this case has three lobes, each having a different lead. Change gears to mill the longest lead are selected and then the angles of elevation of the head and attachment are changed to obtain the shorter leads while using the same change gears.



Milling Slot in Bushing, Using High Speed Milling Attachment

This operation furnishes a good illustration of the use of the high speed milling attachment. The end mill is only $\frac{3}{8}''$ in diameter, and where such small mills are used, it is necessary to run them at much higher speeds than are ordinarily obtainable on the machine, otherwise the finest feeds, either by power or hand, present material to the cutter faster than the teeth can remove it, and as a result, there is constant danger of breaking the mill. With the high speed attachment, the machine spindle speeds are multiplied so that suitable speeds to combine with the available feeds are obtainable.

The bushing being slotted is fastened in the vise at a proper height to bring the slot central.

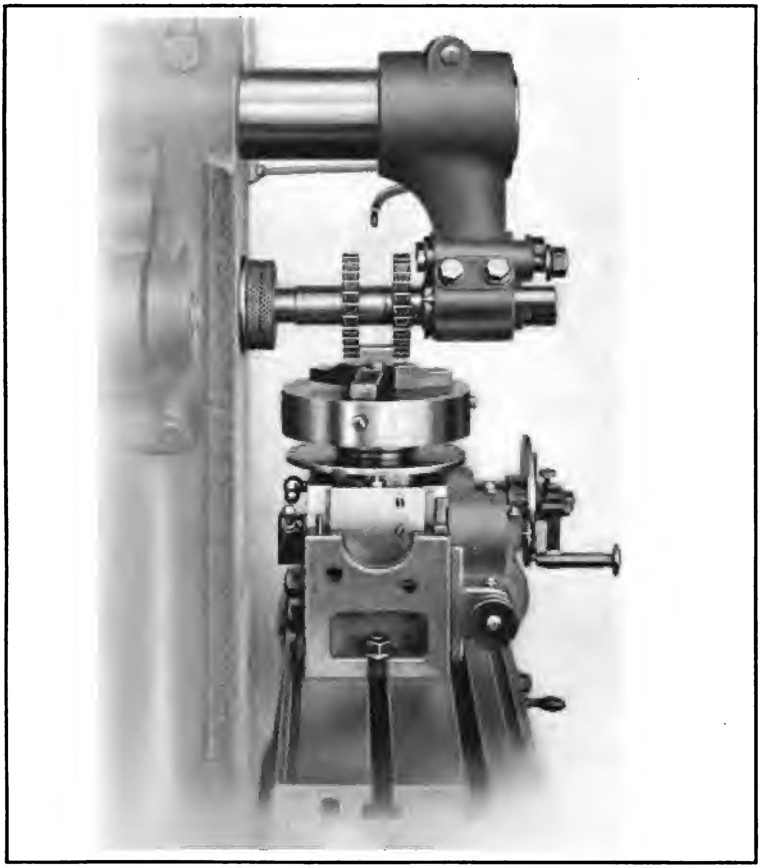


Milling Bearing Surfaces and Splitting Ring

This operation presents an example of light gang milling on work of an interesting character. The ring is required to have two flat bearing surfaces, one at each side of the projection on the top, and to be split midway between these bearings. All three operations are performed simultaneously by the method shown.

The ring is fastened to a knee by means of a nut and large washer in the centre, and clamps at each side prevent the piece from opening when cut through. When these pieces are milled in quantities a fixture is employed to hold them.

Two side milling cutters and a slitting saw comprise the gang.

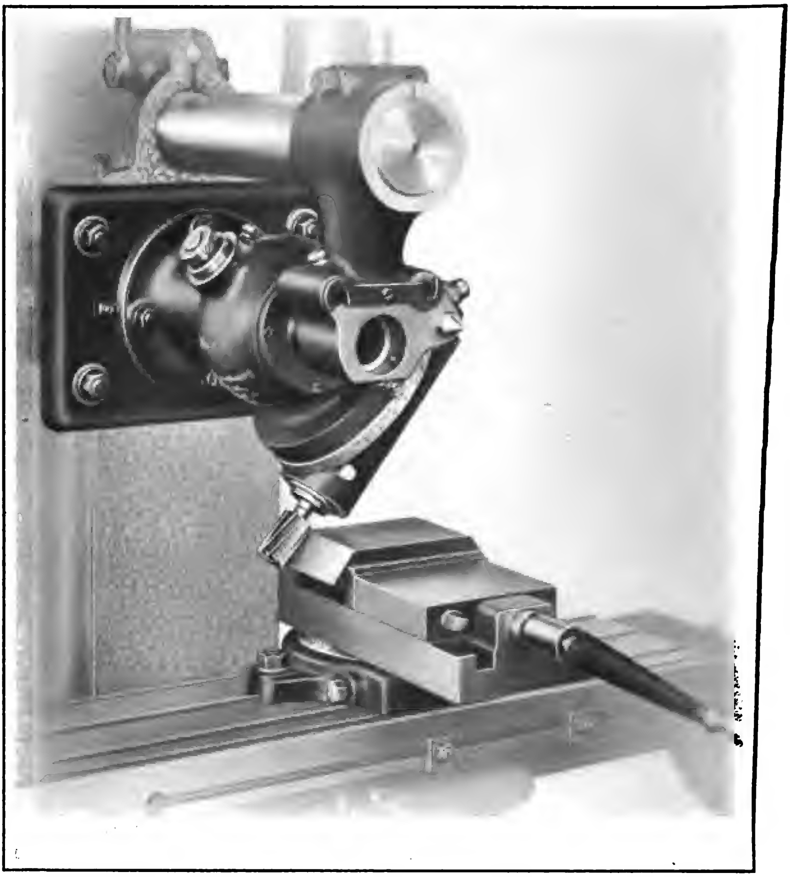


Milling Bolt Heads

The illustration above shows a method of milling the heads of square and hexagonal bolts, using a chuck on the spiral head spindle for clamping the work. It also furnishes a good example of the use of a pair of side milling cutters as "straddle mills." Two sides are finished at a cut, therefore completing a square bolt head with two cuts and a hexagonal one with three cuts.

In indexing the work, the worm of the spiral head is thrown out of mesh and the divisions are obtained from the rapid index plate on the spindle nose.

As the material is of wrought iron, oil is used in cutting.



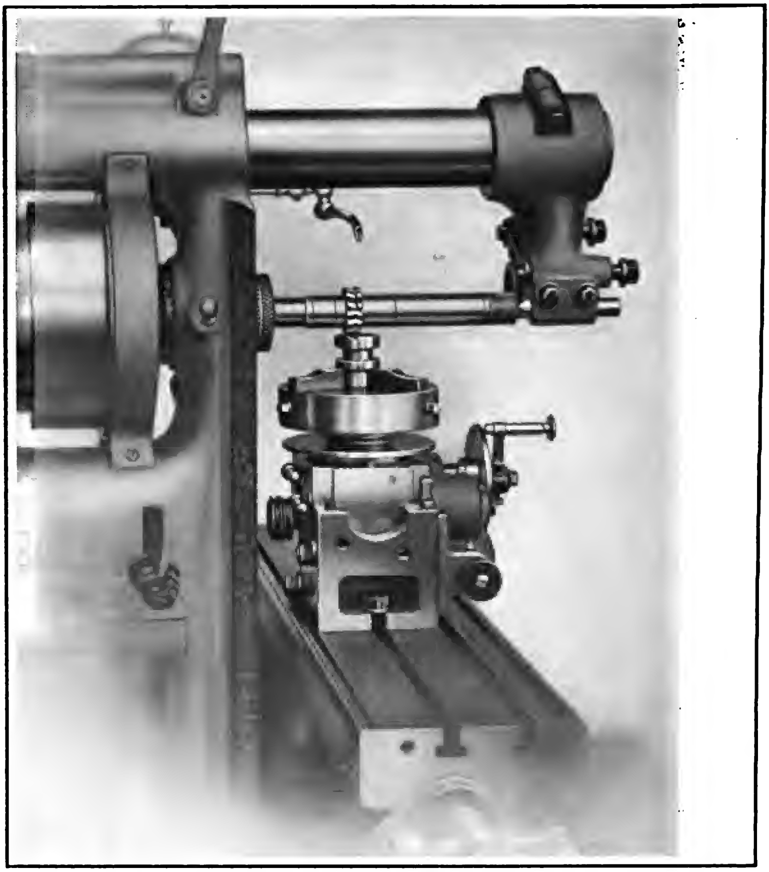
Milling Angle on Block, Using Universal Milling Attachment

This operation is given chiefly to illustrate a use of the Universal Milling Attachment. This attachment may be set in a vertical, horizontal, or angular position without removing any part of it from the machine. Thus the opposite side of the piece of work shown can be milled without removing it from the vise. The table is simply moved to the left and the head of the attachment is swung to the required angle on the opposite side of the vertical.

In this manner both sides are milled so that they are exactly parallel to one another.

Milling Angular Gib, Using Compound Vertical Spindle Milling Attachment

Angular cutters are not always at hand that will produce the proper angle on angular strips, gibs, etc., and when this is the case, the value of a Compound Vertical Spindle Milling Attachment can be appreciated. This attachment can be swung to mill a wide variety of different angles, using an ordinary end mill. It can be used to mill an angle on a long gib, similar to that shown above, or the head can be removed, turned quarter way around and put back in place, and used to mill an angle on a piece where, for some reason, it is advantageous to feed the table transversely.



Milling Clutch Teeth

This operation is very similar in the way it is set up to the one of Milling Bolts previously described. The character of the cut, however, is lighter and the arbor is supported at the outer end on a centre, whereas in the other operation, the end of the arbor runs in the outer bearing. A cutter of special form is used, and one tooth is finished at each cut, the cut beginning at the outside of blank and finishing in the centre.

Indexing in this case is accomplished with the regular index plates and crank as the number of teeth required cannot be indexed with the plate on the spindle nose.

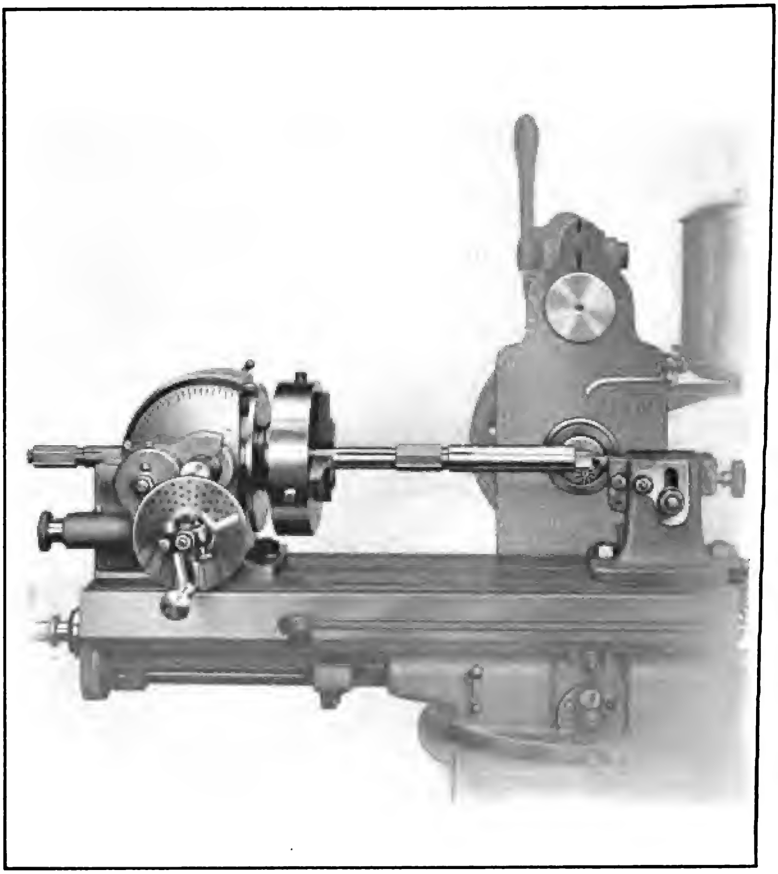
Milling End Teeth in End Mill

When it is required to mill end teeth in an end mill, it may be done as shown in the illustration above.

The mill is held by its shank in a collet that is inserted in the spiral head spindle. The spiral head is adjusted to an angle to give the correct form to the teeth.

An angular cutter is used and the table is fed longitudinally. Indexing is accomplished with the index plates and crank in the usual way.

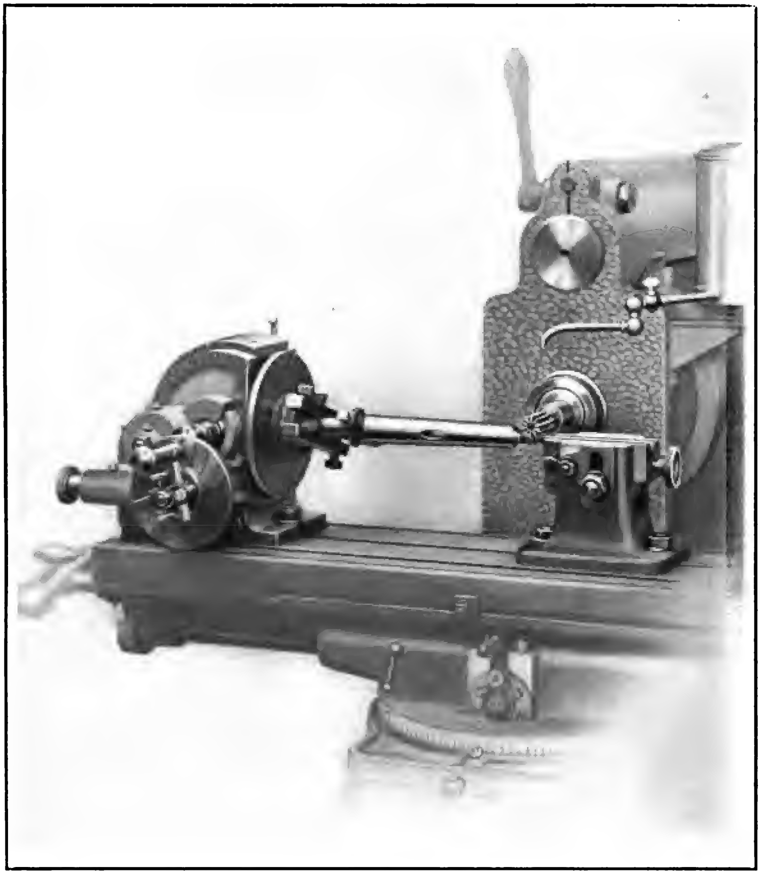
Oil is used, as the material of the end mill is tool steel.



Milling Squares for Wrench on Reamer Shank

A reamer of the type illustrated is necessarily rather long and cannot be accommodated on centres as a shorter piece would be. It is, therefore, passed through the hole in the spiral head spindle and is clamped in the chuck, while the wrench end is supported by the footstock centre.

An end mill is used and the work is fed vertically. To prevent longitudinal movement of table, the small clamping lever shown on the front of the saddle is set up. Where there are many pieces to be done, a more permanent method of fixing the table is by means of stops that fasten on to the V bearing at the bottom of the table and come against the side of the saddle.



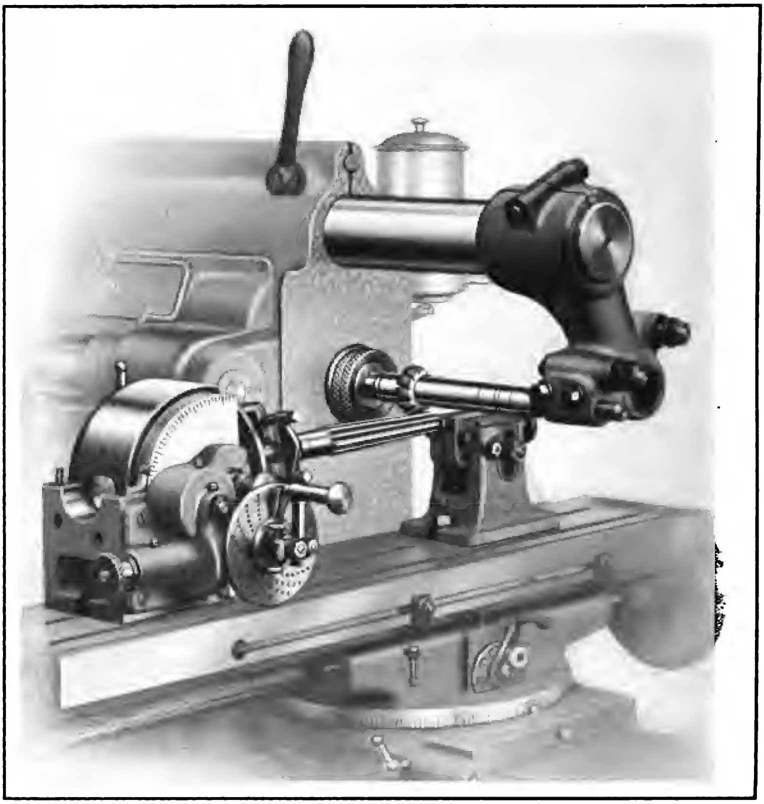
Milling Tenon on Collet

A taper plug having a centre hole at the large end is driven into the hole in the collet, which is then mounted on the spiral head centres. A dog on the taper plug locks the collet to the spiral head spindle.

An end mill is used and the cutting is done with the teeth on the periphery. The rapid index plate is used to index the work and the table is fed longitudinally.

The table feed trip dog is set to insure milling both sides to the same length.

If a quantity of this work is to be done, formed straddle mills would be employed with an entirely different arrangement.

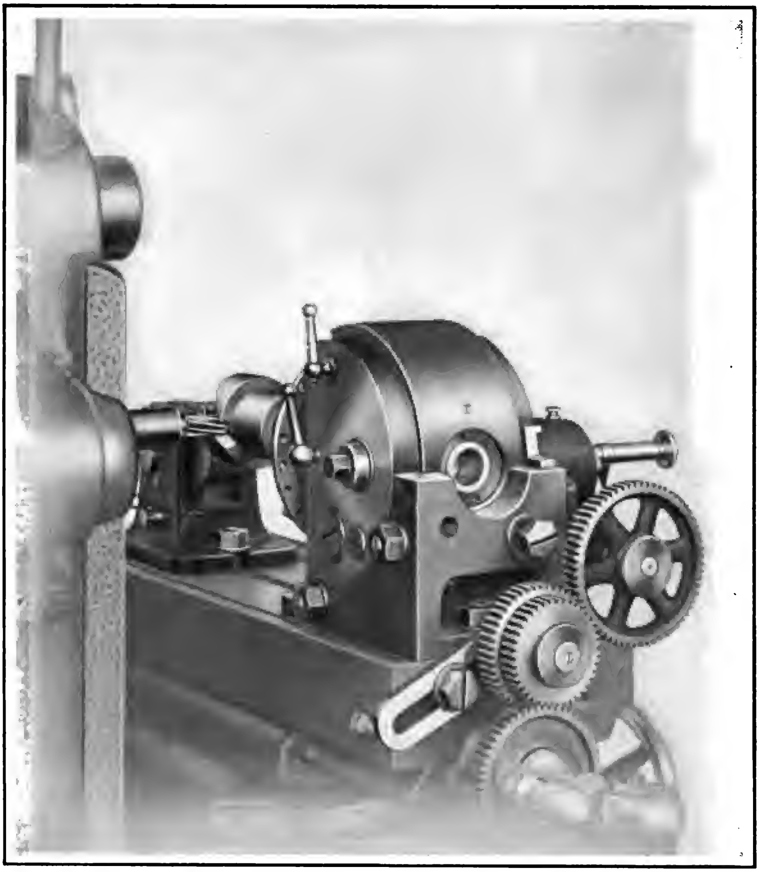


Milling Flutes in Taper Reamer

There are times when a shop requires a reamer of special size that cannot be procured readily, and in such cases one can be turned up and the flutes cut in the manner shown above. The spiral head is set at the angle of taper and the foot-stock centre is adjusted to correspond with it. The reamer blank is then mounted on the centres and dogged to the spiral head spindle.

A stock cutter, known as a reamer fluting cutter, is used and the table is fed longitudinally.

The procedure is the same for milling a straight reamer, except that the spiral head and foot-stock are set at zero.



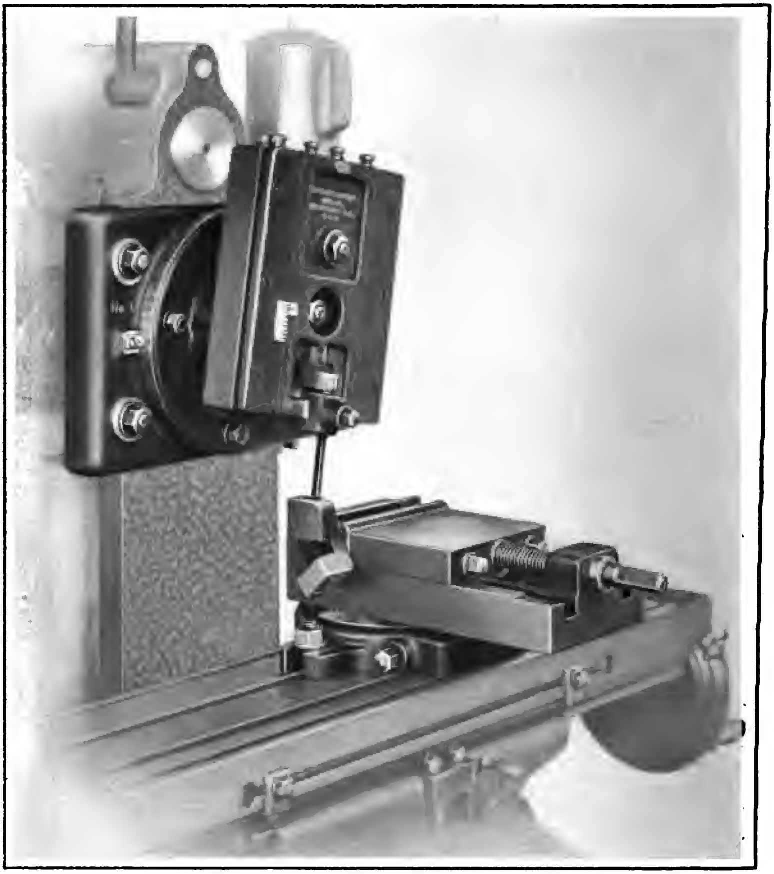
Cutting a Spiral with End Mill

When a spiral slot with parallel sides is required an end mill should be employed and the job set up as shown above.

The spiral head centres are brought to a level with the centre of the machine spindle.

The table is at right angles to the spindle and the angle of the spiral is obtained by the combination of change gears used.

Either right or left-hand spirals can be cut in this way by simply leaving out or interposing an intermediate gear in the train of change gears.

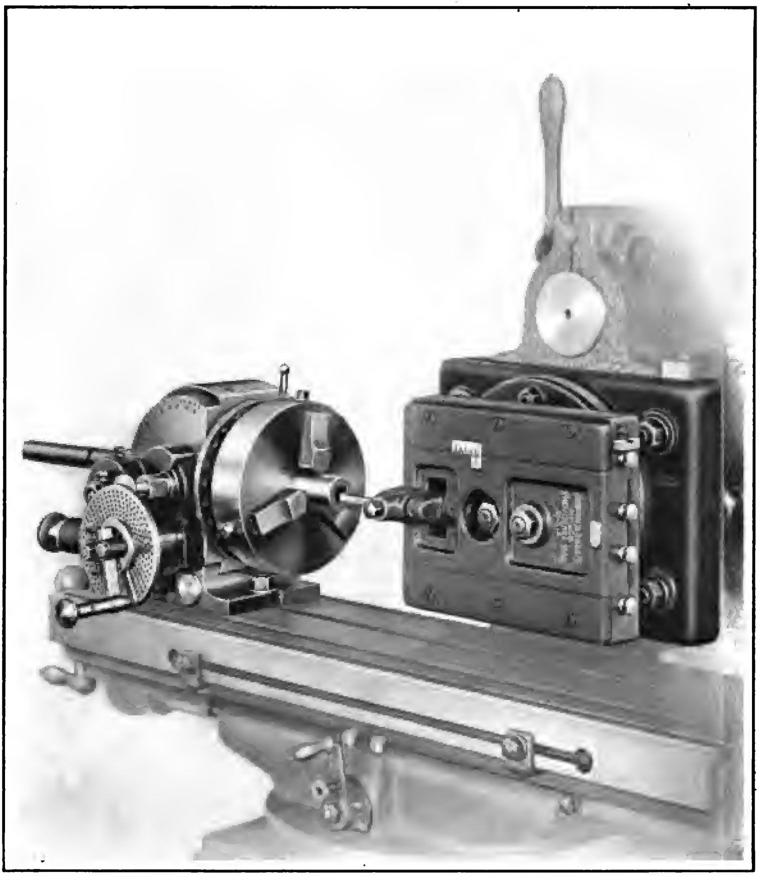


Cutting Slots in Screw Machine Tool, Using Slotting Attachment

The screw machine tool is held by its shank in a vise; and the slotting attachment is set at an angle so as to give the proper clearance to the cutter that is intended for use in the slot. A hole is drilled for starting the slot.

In slotting work, all necessary movements of the table are made by the hand feed.

The swivel vise is very useful in connection with the slotting attachment, for the work can be swung to any angle or indexed, if it is desired to make a special shaped slot.

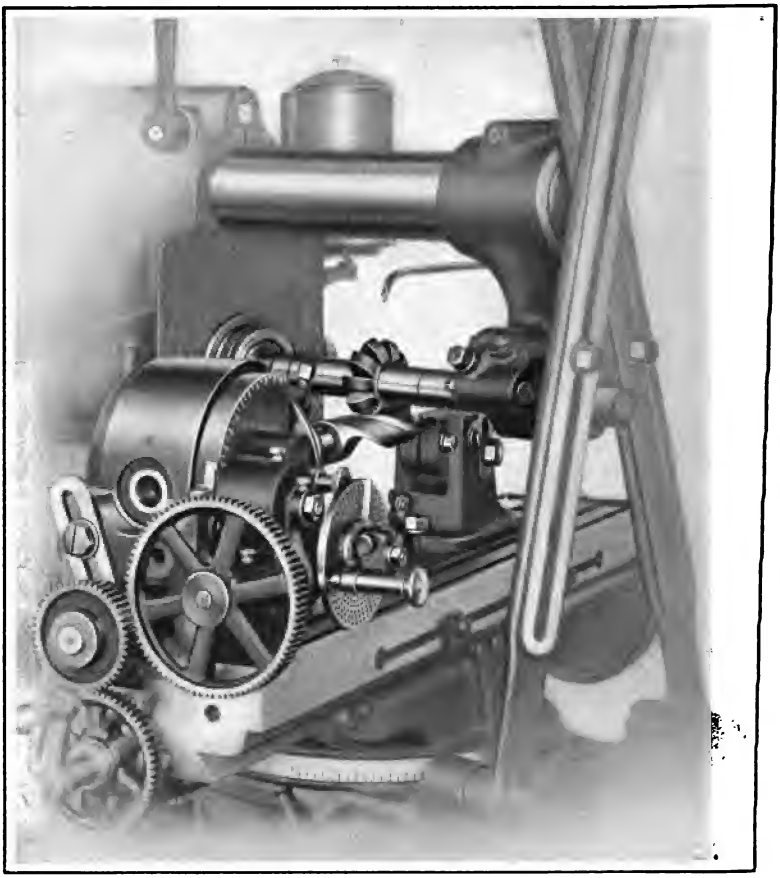


Slotting Square Hole in Extension Wrench

In this operation the piece of work is too long to be set in a vertical position; it is, therefore, passed through the spiral head spindle and is clamped in the chuck. The slotting attachment head is then set so that the tool moves in a path parallel to the top of the table.

The ability to swing the head from a vertical to a horizontal position is one of the features of the B. & S. attachment.

The piece of work is indexed by means of the rapid index plate. All necessary movements of the table are made by hand.

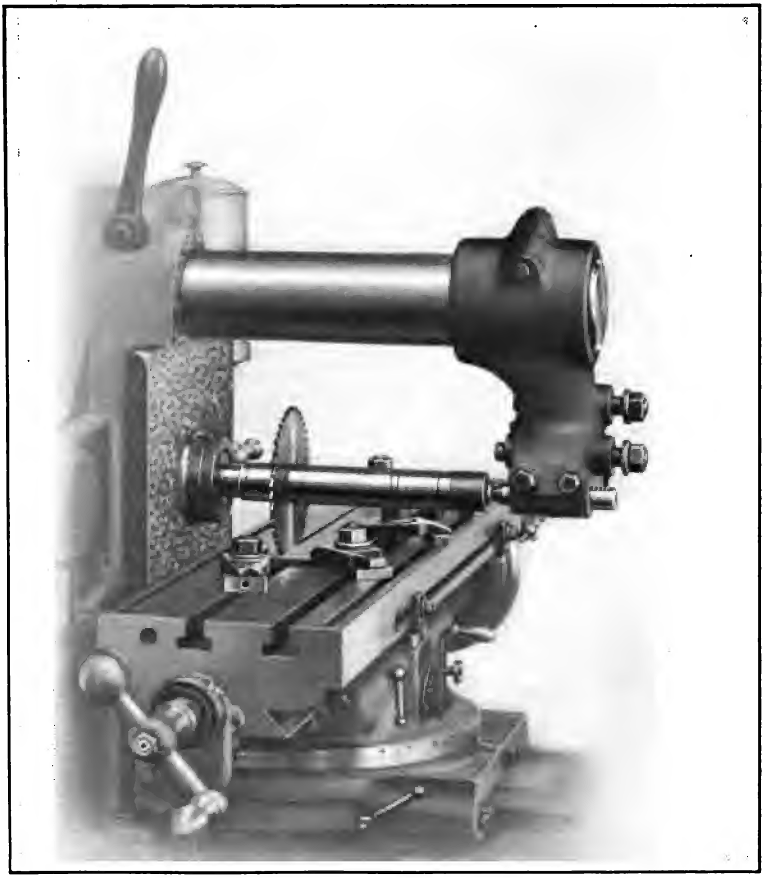


Milling Flutes of Twist Drill

This operation is very similar to that of cutting a spiral gear. The drill blank is mounted on the spiral head centres and fastened to the spindle with a dog. The spiral head is geared for the required lead and the necessary angle is obtained by swinging the swivel table.

As the character of the cut is heavy, the arm braces are employed to give additional rigidity to the arbor. A stock cutter of special form, known as a twist drill cutter, is employed and oil is used in cutting.

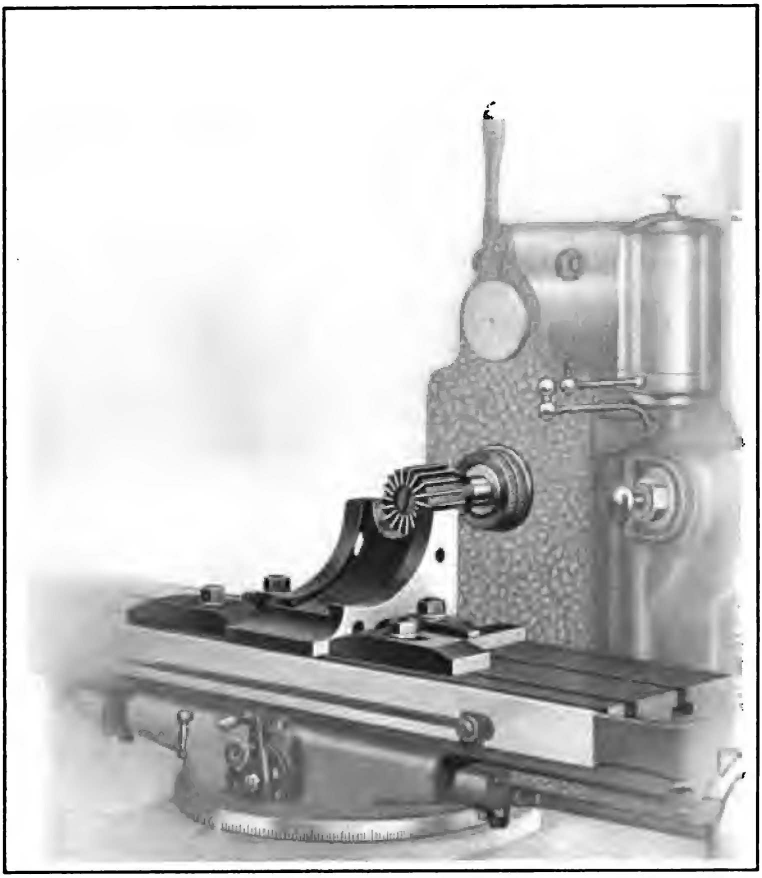
More complete information on this subject can be found in Chapter IV.



Sawing Flat Stock

When it is necessary to saw a piece of flat stock, it may be strapped directly to the table in a position so that the line where it is to be cut comes over a slot.

A metal slitting saw is used to split the piece and the table is fed in the same direction to that in which the saw revolves. This prevents the tendency to raise the work from the table and wedge the cutter; also for the cut to run out of a straight line. In feeding the table in this manner, every precaution should be taken to eliminate backlash from the feed screw.

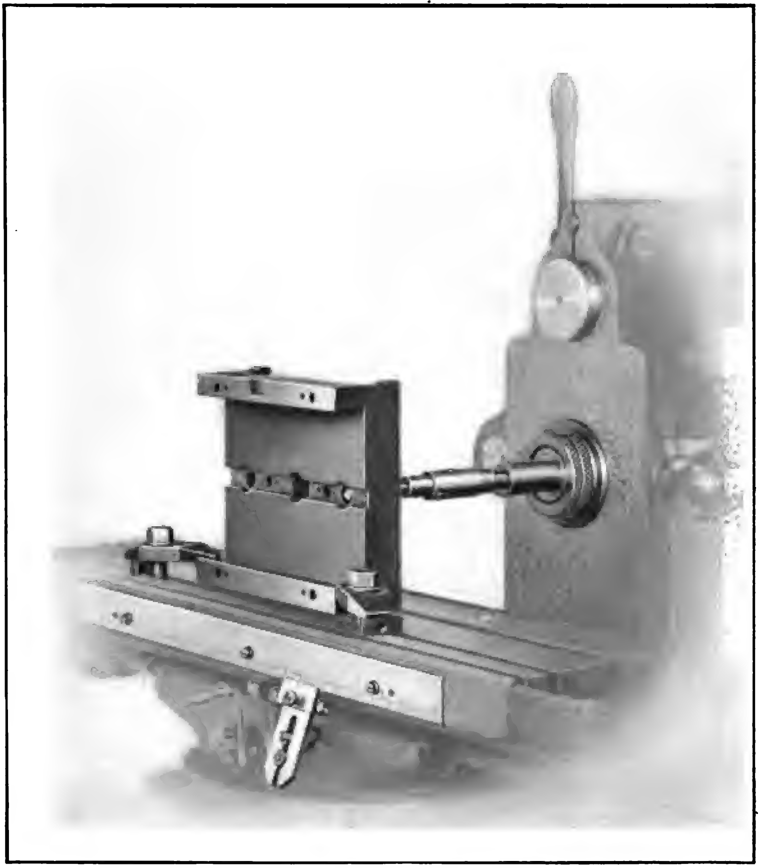


Milling Semi-Circle in Top of Spiral Head Base

The casting is clamped directly to the table, as clearly shown in the illustration, and the knee is raised so that the top of the piece is in a line with the axis of the cutter.

A shell end mill is used and the table is fed transversely, bringing all the cutting upon the end teeth of the mill.

When a mill is used in this manner, it is well to grind the teeth on the periphery a little smaller at the back end, as this has a tendency to prevent chattering.



Boring Holes in Jig

The use of a scale and vernier in connection with a boring bar is shown in this operation boring holes where accurate spacing is required. Finer adjustments can be obtained in this way than are possible using the dial on the longitudinal hand feed screw.

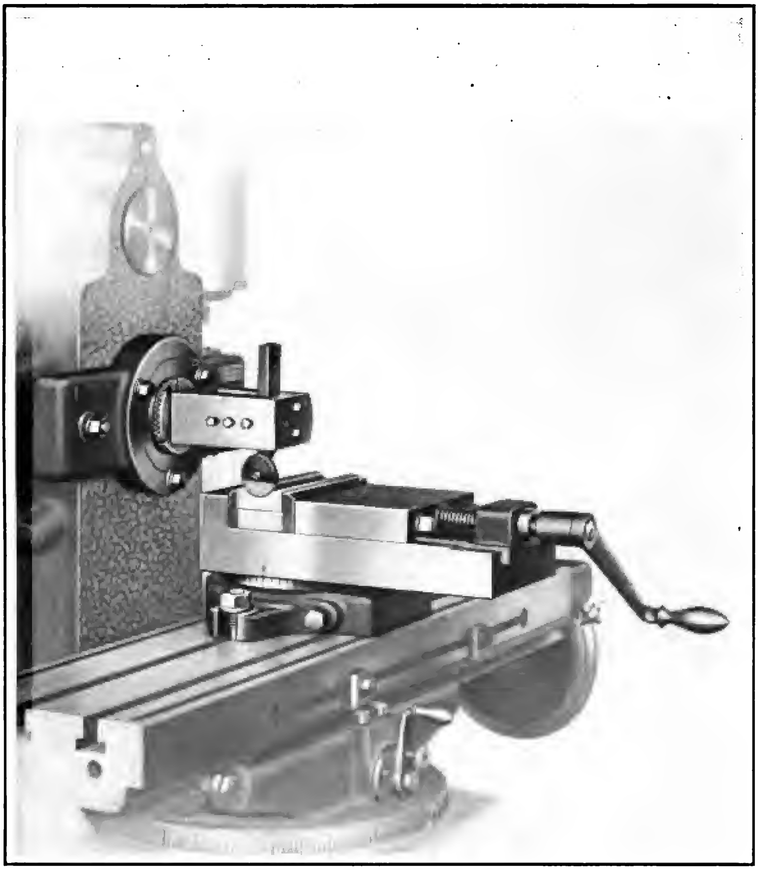
The work is strapped to the table, and the boring bar, which is in reality a kind of fly tool, is held in a collet inserted in the spindle. Scales and verniers can also be furnished for the transverse and vertical movements of Brown & Sharpe milling machines.

Milling Curved and Flat Surfaces at one Setting of Work, Using Vertical Spindle and Circular Milling Attachments

A combination of a vertical spindle and circular milling attachment is shown in this operation. With these two attachments, practically the same variety of work can be done as on a vertical spindle milling machine of equal capacity.

The job being done consists of milling a flat surface on the top of a piece and a curved surface at the end of it. The piece is set over a bushing inserted in the centre of the circular milling attachment table. The work is fed in a circular path by means of the hand-wheel, and when the flat cut is finished, the machine table is raised for milling the curved surface, but the work is not disturbed.

With a vertical spindle milling machine, only the circular milling attachment is needed.

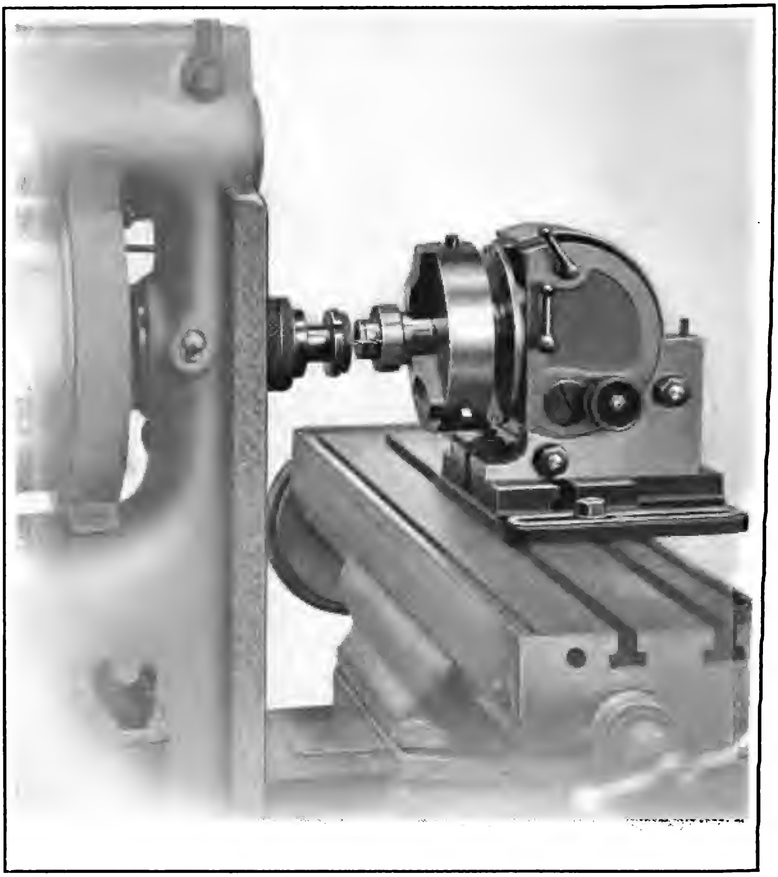


Planing on a Milling Machine

This illustration shows a comparatively unusual operation on the milling machine. Planing can be done on any milling machine by clamping the spindle and moving the table by hand; but on our constant speed drive machines, the spindle can be clamped and the power feeds for longitudinal movement of table are still available.

The special device for clamping the spindle consists of a split ring that screws on the threaded nose of the spindle, over which a bracket is clamped to the column. A bevel sleeve contained in the bracket closes the split ring on the spindle when the three bolts are tightened.

A fly tool is used, and if power feed is utilized, the table is usually fed at its fastest feed. The work is fed upward or transversely by means of the vertical or transverse hand feeds—often both are employed.



Drilling Holes in Bushing

A method of drilling holes in round pieces of work where they are required to be exactly spaced is shown in this operation.

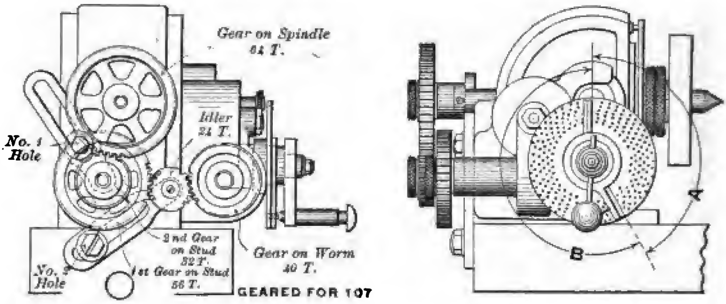
The bushing is held in the spiral head chuck and is indexed in the regular way, or with the rapid index plate, if the number of holes required can be obtained by the latter.

An ordinary twist drill, held in a spring chuck, is employed and the table is usually fed by hand. A collet can be employed for a drill having a taper shank.

TABLES

INDEX TABLE 2 to 50

PLAIN & DIFFERENTIAL INDEXING



NUMBER OF DIVISIONS	INDEX CIRCLE	No. OF TURNS OF INDEX	GRADUATION
2	Any	20	
3	39	$13\frac{13}{39}$	65
	33	$13\frac{11}{33}$	65
	18	$13\frac{6}{18}$	65
4	Any	10	
5	Any	8	
6	39	$6\frac{26}{39}$	132
	33	$6\frac{22}{33}$	132
	18	$6\frac{12}{18}$	132
7	49	$5\frac{35}{49}$	140
	21	$5\frac{15}{21}$	142
8	Any	5	
9	27	$4\frac{12}{27}$	88
	18	$4\frac{8}{18}$	87
10	Any	4	
11	33	$3\frac{21}{33}$	126
12	39	$3\frac{13}{39}$	65
	33	$3\frac{11}{33}$	65
	18	$3\frac{6}{18}$	65

NUMBER OF DIVISIONS	INDEX CIRCLE	No. OF TURNS OF INDEX	GRADUATION
13	39	$3\frac{3}{39}$	14
14	49	$2\frac{42}{49}$	169
	21	$2\frac{18}{21}$	170
15	39	$2\frac{26}{39}$	132
	33	$2\frac{22}{33}$	132
	18	$2\frac{12}{18}$	132
16	20	$2\frac{10}{20}$	98
17	17	$2\frac{6}{17}$	69
18	27	$2\frac{6}{27}$	43
	18	$2\frac{4}{18}$	43
19	19	$2\frac{2}{19}$	19
20	Any	2	
21	21	$1\frac{19}{21}$	18*
22	33	$1\frac{27}{33}$	161
23	23	$1\frac{17}{23}$	147
24	39	$1\frac{26}{39}$	132
	33	$1\frac{22}{33}$	132
	18	$1\frac{12}{18}$	132
25	20	$1\frac{12}{20}$	118

NUMBER OF DIVISIONS	INDEX CIRCLE	No. OF TURNS OF INDEX	GRADUATION
26	39	$1\frac{21}{39}$	106
27	27	$1\frac{13}{27}$	95
28	49	$1\frac{21}{49}$	83
	21	$1\frac{9}{21}$	85
29	29	$1\frac{11}{29}$	75
30	39	$1\frac{13}{39}$	65
	33	$1\frac{11}{33}$	65
	18	$1\frac{6}{18}$	65
31	31	$1\frac{9}{31}$	56
32	20	$1\frac{5}{20}$	48
33	33	$1\frac{7}{33}$	41
34	17	$1\frac{3}{17}$	33
35	49	$1\frac{7}{49}$	26
	21	$1\frac{3}{21}$	28
36	27	$1\frac{3}{27}$	21
	18	$1\frac{2}{18}$	21
37	37	$1\frac{3}{37}$	15
38	19	$1\frac{1}{19}$	9
39	39	$1\frac{1}{39}$	3

NUMBER OF DIVISIONS	INDEX CIRCLE	No. OF TURNS OF INDEX	GRADUATION
40	Any	1	
41	41	$\frac{40}{41}$	3*
42	21	$\frac{20}{21}$	9*
43	43	$\frac{40}{43}$	12*
44	33	$\frac{30}{33}$	17*
45	27	$\frac{24}{27}$	21*
	18	$\frac{16}{18}$	21*
46	23	$\frac{20}{23}$	172
47	47	$\frac{40}{47}$	168
48	18	$\frac{15}{18}$	165
49	49	$\frac{40}{49}$	161
50	20	$\frac{16}{20}$	158

GRADUATIONS IN TABLE INDICATE SETTING FOR ARMS OF SECTOR WHEN INDEX CRANK MOVES THROUGH ARC "A," EXCEPT CASES MARKED * WHEN THE INDEX CRANK MOVES THROUGH ARC "B."

INDEX TABLE 51 to 92.

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
51	17	$\frac{14}{17}$	33*	24			48	24	44
52	39	$\frac{30}{39}$	152						
53	49	$\frac{35}{49}$	140	56	40	24	72		
	21	$\frac{15}{21}$	142	56	40	24	72		
54	27	$\frac{20}{27}$	147						
55	33	$\frac{24}{33}$	144						
56	49	$\frac{35}{49}$	140						
	21	$\frac{15}{21}$	142						
57	49	$\frac{35}{49}$	140	56			40	24	44
	21	$\frac{15}{21}$	142	56			40	24	44
58	29	$\frac{20}{29}$	136						
59	39	$\frac{26}{39}$	132	48			32	44	
	33	$\frac{22}{33}$	132	48			32	44	
	18	$\frac{12}{18}$	132	48			32	44	
60	39	$\frac{26}{39}$	132						
	33	$\frac{22}{33}$	132						
	18	$\frac{12}{18}$	132						
61	39	$\frac{26}{39}$	132	48			32	24	44
	33	$\frac{22}{33}$	132	48			32	24	44
	18	$\frac{12}{18}$	132	48			32	24	44
62	31	$\frac{20}{31}$	127						
63	39	$\frac{26}{39}$	132	24			48	24	44
	33	$\frac{22}{33}$	132	24			48	24	44
	18	$\frac{12}{18}$	132	24			48	24	44
64	16	$\frac{10}{16}$	123						
65	39	$\frac{24}{39}$	121						
66	33	$\frac{20}{33}$	120						
67	49	$\frac{28}{49}$	112	28			48	44	
	21	$\frac{12}{21}$	113	28			48	44	
68	17	$\frac{10}{17}$	116						

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
69	20	$\frac{12}{20}$	118	40			56	24	44
70	49	$\frac{28}{49}$	112						
	21	$\frac{12}{21}$	113						
71	27	$\frac{15}{27}$	110	72			40	24	
	18	$\frac{10}{18}$	109	72			40	24	
72	27	$\frac{15}{27}$	110						
	18	$\frac{10}{18}$	109						
73	49	$\frac{28}{49}$	112	28			48	24	44
	21	$\frac{12}{21}$	113	28			48	24	44
74	37	$\frac{20}{37}$	107						
75	15	$\frac{8}{15}$	105						
76	19	$\frac{10}{19}$	103						
77	20	$\frac{10}{20}$	98	32			48	44	
78	39	$\frac{20}{39}$	101						
79	20	$\frac{10}{20}$	98	48			24	44	
80	20	$\frac{10}{20}$	98						
81	20	$\frac{10}{20}$	98	48			24	24	44
82	41	$\frac{20}{41}$	96						
83	26	$\frac{10}{20}$	98	32			48	24	44
84	21	$\frac{10}{21}$	94						
85	17	$\frac{8}{17}$	92						
86	43	$\frac{20}{43}$	91						
87	15	$\frac{7}{15}$	92	40			24	24	44
88	33	$\frac{15}{33}$	89						
89	27	$\frac{12}{27}$	88	72			32	44	
	18	$\frac{8}{18}$	87	72			32	44	
90	27	$\frac{12}{27}$	88						
	18	$\frac{8}{18}$	87						
91	39	$\frac{18}{39}$	91	24			48	24	44
92	23	$\frac{10}{23}$	86						

INDEX TABLE 93 to 125.

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
93	27	12/27	88	24			32	24	44	114	39	13/39	65	24			48	44	
	18	8/18	87	24			32	24	44		33	11/33	65	24			48	44	
94	47	20/47	83								18	6/18	65	24			48	44	
95	19	8/19	82							115	23	8/23	68						
96	49	21/49	83	28			32	24	44	116	29	10/29	68						
	21	9/21	85	28			32	24	44	117	39	13/39	65	24			24	56	
97	20	8/20	78	40			48	44			33	11/33	65	24			24	56	
98	49	20/49	79								18	6/18	65	24			24	56	
99	20	8/20	78	56	28	40	32			118	39	13/39	65	48			32	44	
100	20	8/20	78								33	11/33	65	48			32	44	
101	20	8/20	78	72	24	40	48		24		18	6/18	65	48			32	44	
102	20	8/20	78	40			32	24	44	119	39	13/39	65	72			24	44	
103	20	8/20	78	40			48	24	44		33	11/33	65	72			24	44	
104	39	15/39	75								18	6/18	65	72			24	44	
105	21	8/21	75							120	39	13/39	65						
106	43	16/43	73	86	24	24	48				33	11/33	65						
107	20	8/20	78	40	56	32	64		24		18	6/18	65						
108	27	10/27	73							121	39	13/39	65	72			24	24	44
109	16	6/16	73	32			28	24	44		33	11/33	65	72			24	24	44
110	33	12/33	71								18	6/18	65	72			24	24	44
111	39	13/39	65	24			72	32		122	39	13/39	65	48			32	24	44
	33	11/33	65	24			72	32			33	11/33	65	48			32	24	44
	18	6/18	65	24			72	32			18	6/18	65	48			32	24	44
112	39	13/39	65	24			64	44		123	39	13/39	65	24			24	24	44
	33	11/33	65	24			64	44			33	11/33	65	24			24	24	44
	18	6/18	65	24			64	44			18	6/18	65	24			24	24	44
113	39	13/39	65	24			56	44		124	31	10/31	63						
	33	11/33	65	24			56	44		125	39	13/39	65	24			40	24	44
	18	6/18	65	24			56	44			33	11/33	65	24			40	24	44
											18	6/18	65	24			40	24	44

INDEX TABLE 126 to 168.

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
126	39	13/39	65	24			48	24	44	143	49	14/49	55	28			24	24	44
	33	11/33	65	24			48	24	44		21	6/21	56	28			24	24	44
	18	6/18	65	24			48	24	44	144	18	5/18	54						
127	39	13/39	65	24			56	24	44	145	29	8/29	54						
	33	11/33	65	24			56	24	44	146	49	14/49	55	28			48	24	44
	18	6/18	65	24			56	24	44		21	6/21	56	28			48	24	44
128	16	5/16	61							147	49	14/49	55	24			48	24	44
129	39	13/39	65	24			72	24	44		21	6/21	56	24			48	24	44
	33	11/33	65	24			72	24	44	148	37	10/37	53						
	18	6/18	65	24			72	24	44	149	49	14/49	55	28			72	24	44
130	39	12/39	60								21	6/21	56	28			72	24	44
131	20	6/20	58	40			28	44		150	15	4/15	52						
132	33	10/33	59							151	20	5/20	48	32			72	44	
133	49	14/49	55	24			48	44		152	19	5/19	51						
	21	6/21	56	24			48	44		153	20	5/20	48	32			56	44	
134	49	14/49	55	28			48	44		154	20	5/20	48	32			48	44	
	21	6/21	56	28			48	44		155	31	8/31	50						
135	27	8/27	58							156	39	10/39	50						
136	17	5/17	57							157	20	5/20	48	32			24	56	
137	49	14/49	55	28			24	56		158	20	5/20	48	48			24	44	
	21	6/21	56	28			24	56		159	20	5/20	48	64	32	56	28		
138	49	14/49	55	56			32	44		160	20	5/20	48						
	21	6/21	56	56			32	44		161	20	5/20	48	64	32	56	28		24
139	49	14/49	55	56	32	48	24			162	20	5/20	48	48			24	24	44
	21	6/21	56	56	32	48	24			163	20	5/20	48	32			24	24	44
140	49	14/49	55							164	41	10/41	47						
	21	6/21	56							165	33	8/33	47						
141	18	5/18	54	48			40	44		166	20	5/20	48	32			48	24	44
142	49	14/49	55	56			32	24	44	167	20	5/20	48	32			56	24	44
	21	6/21	56	56			32	24	44	168	21	5/21	47						

INDEX TABLE 169 to 214.

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
169	20	$\frac{5}{20}$	48	32			72	24	44	187	27	$\frac{6}{27}$	43	72	48	24	56		24
170	17	$\frac{4}{17}$	45								18	$\frac{4}{18}$	43	72	48	24	56		24
171	21	$\frac{5}{21}$	47	56			40	24	44	188	47	$\frac{10}{47}$	40						
172	43	$\frac{10}{43}$	44							189	27	$\frac{6}{27}$	43	32			64	24	44
173	27	$\frac{6}{27}$	43	72	56	32	64				18	$\frac{4}{18}$	43	32			64	24	44
	18	$\frac{4}{18}$	43	72	56	32	64			190	19	$\frac{4}{19}$	40						
174	27	$\frac{6}{27}$	43	24			32	56		191	20	$\frac{4}{20}$	38	40			72	24	
	18	$\frac{4}{18}$	43	24			32	56		192	20	$\frac{4}{20}$	38	40			64	44	
175	27	$\frac{6}{27}$	43	72	40	32	64			193	20	$\frac{4}{20}$	38	40			56	44	
	18	$\frac{4}{18}$	43	72	40	32	64			194	20	$\frac{4}{20}$	38	40			48	44	
176	27	$\frac{6}{27}$	43	72	24	24	64			195	39	$\frac{8}{39}$	39						
	18	$\frac{4}{18}$	43	72	24	24	64			196	49	$\frac{10}{49}$	38						
177	27	$\frac{6}{27}$	43	72			48	24		197	20	$\frac{4}{20}$	38	40			24	56	
	18	$\frac{4}{18}$	43	72			48	24		198	20	$\frac{4}{20}$	38	56	28	40	32		
178	27	$\frac{6}{27}$	43	72			32	44		199	20	$\frac{4}{20}$	38	100	40	64	32		
	18	$\frac{4}{18}$	43	72			32	44		200	20	$\frac{4}{20}$	38						
179	27	$\frac{6}{27}$	43	72	24	48	32			201	20	$\frac{4}{20}$	38	72	24	40	24		24
	18	$\frac{4}{18}$	43	72	24	48	32			202	20	$\frac{4}{20}$	38	72	24	40	48		24
180	27	$\frac{6}{27}$	43							203	20	$\frac{4}{20}$	38	40			24	24	44
	18	$\frac{4}{18}$	43							204	20	$\frac{4}{20}$	38	40			32	24	44
181	27	$\frac{6}{27}$	43	72	24	48	32		24	205	41	$\frac{8}{41}$	37						
	18	$\frac{4}{18}$	43	72	24	48	32		24	206	20	$\frac{4}{20}$	38	40			48	24	44
182	27	$\frac{6}{27}$	43	72			32	24	44	207	20	$\frac{4}{20}$	38	40			56	24	44
	18	$\frac{4}{18}$	43	72			32	24	44	208	20	$\frac{4}{20}$	38	40			64	24	44
183	27	$\frac{6}{27}$	43	48			32	24	44	209	20	$\frac{4}{20}$	38	40			72	24	44
	18	$\frac{4}{18}$	43	48			32	24	44	210	21	$\frac{4}{21}$	37						
184	23	$\frac{5}{23}$	42							211	16	$\frac{3}{16}$	36	64			28	44	
185	37	$\frac{8}{37}$	42							212	43	$\frac{8}{43}$	35	86	24	24	48		
186	27	$\frac{6}{27}$	43	48			64	24	44	213	27	$\frac{5}{27}$	36	72			40	44	
	18	$\frac{4}{18}$	43	48			64	24	44	214	20	$\frac{4}{20}$	38	40	56	32	64		24

INDEX TABLE 215 to 270.

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
215	43	$\frac{8}{43}$	35							245	49	$\frac{8}{49}$	30						
216	27	$\frac{5}{27}$	36							246	18	$\frac{3}{18}$	32	24			24	24	44
217	21	$\frac{4}{21}$	37	48			64	24	44	247	18	$\frac{3}{18}$	32	48			56	24	44
218	16	$\frac{3}{16}$	36	64			56	24	44	248	31	$\frac{5}{31}$	31						
219	21	$\frac{4}{21}$	37	28			48	24	44	249	18	$\frac{3}{18}$	32	32			48	24	44
220	33	$\frac{6}{33}$	35							250	18	$\frac{3}{18}$	32	24			40	24	44
221	17	$\frac{3}{17}$	33	24			24	56		251	18	$\frac{3}{18}$	32	48	44	32	64		24
222	18	$\frac{3}{18}$	32	24			72	44		252	18	$\frac{3}{18}$	32	24			48	24	44
223	43	$\frac{8}{43}$	35	86	48	24	64		24	253	33	$\frac{5}{33}$	29	24			40	56	
224	18	$\frac{3}{18}$	32	24			64	44		254	18	$\frac{3}{18}$	32	24			56	24	44
225	27	$\frac{5}{27}$	36	24			40	24	44	255	18	$\frac{3}{18}$	32	48	40	24	72		24
226	18	$\frac{3}{18}$	32	24			56	44		256	18	$\frac{3}{18}$	32	24			64	24	44
227	49	$\frac{8}{49}$	30	56	64	28	72			257	49	$\frac{8}{49}$	30	56	48	28	64		24
228	18	$\frac{3}{18}$	32	24			48	44		258	43	$\frac{7}{43}$	31	32			64	24	44
229	18	$\frac{3}{18}$	32	24			44	48		259	49	$\frac{7}{49}$	26	24			72	44	
230	23	$\frac{4}{23}$	34								21	$\frac{3}{21}$	28	24			72	44	
231	18	$\frac{3}{18}$	32	32			48	44		260	39	$\frac{6}{39}$	29						
232	29	$\frac{5}{29}$	33							261	29	$\frac{4}{29}$	26	48	64	24	72		
233	18	$\frac{3}{18}$	32	48			56	44		262	20	$\frac{3}{20}$	28	40			28	44	
234	18	$\frac{3}{18}$	32	24			24	56		263	49	$\frac{8}{49}$	30	56	64	28	72		24
235	47	$\frac{8}{47}$	32							264	33	$\frac{5}{33}$	29						
236	18	$\frac{3}{18}$	32	48			32	44		265	49	$\frac{7}{49}$	26	56	40	24	72		
237	18	$\frac{3}{18}$	32	48			24	44			21	$\frac{3}{21}$	28	56	40	24	72		
238	18	$\frac{3}{18}$	32	72			24	44		266	49	$\frac{7}{49}$	26	32			64	44	
239	18	$\frac{3}{18}$	32	72	24	64	32				21	$\frac{3}{21}$	28	32			64	44	
240	18	$\frac{3}{18}$	32							267	27	$\frac{4}{27}$	28	72			32	44	
241	18	$\frac{3}{18}$	32	72	24	64	32		24	268	49	$\frac{7}{49}$	26	28			48	44	
242	18	$\frac{3}{18}$	32	72			24	24	44		21	$\frac{3}{21}$	28	28			48	44	
243	18	$\frac{3}{18}$	32	64			32	24	44	269	20	$\frac{3}{20}$	28	64	32	40	28		24
244	18	$\frac{3}{18}$	32	48			32	24	44	270	27	$\frac{4}{27}$	28						

INDEX TABLE 271 to 310

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No.1 Hole: 1st Gear on Stud	No.1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
271	49	$\frac{7}{49}$	26	56			72	24	
	21	$\frac{3}{21}$	28	56			72	24	
272	49	$\frac{7}{49}$	26	56			64	24	
	21	$\frac{3}{21}$	28	56			64	24	
273	49	$\frac{7}{49}$	26	24			24	56	
	21	$\frac{3}{21}$	28	24			24	56	
274	49	$\frac{7}{49}$	26	56			48	44	
	21	$\frac{3}{21}$	28	56			48	44	
275	49	$\frac{7}{49}$	26	56			40	44	
	21	$\frac{3}{21}$	28	56			40	44	
276	49	$\frac{7}{49}$	26	56			32	44	
	21	$\frac{3}{21}$	28	56			32	44	
277	49	$\frac{7}{49}$	26	56			24	44	
	21	$\frac{3}{21}$	28	56			24	44	
278	49	$\frac{7}{49}$	26	56	32	48	24		
	21	$\frac{3}{21}$	28	56	32	48	24		
279	27	$\frac{4}{27}$	28	24			32	24	44
280	49	$\frac{7}{49}$	26						
	21	$\frac{3}{21}$	28						
281	49	$\frac{7}{49}$	26	72	24	56	24		24
	21	$\frac{3}{21}$	28	72	24	56	24		24
282	43	$\frac{6}{43}$	26	86	24	24	56		
283	49	$\frac{7}{49}$	26	56			24	24	44
	21	$\frac{3}{21}$	28	56			24	24	44
284	49	$\frac{7}{49}$	26	56			32	24	44
	21	$\frac{3}{21}$	28	56			32	24	44
285	49	$\frac{7}{49}$	26	56			40	24	44
	21	$\frac{3}{21}$	28	56			40	24	44
286	49	$\frac{7}{49}$	26	56			48	24	44
	21	$\frac{3}{21}$	28	56			48	24	44

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No.1 Hole: 1st Gear on Stud	No.1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
287	49	$\frac{7}{49}$	26	24			24	24	44
	21	$\frac{3}{21}$	28	24			24	24	44
288	49	$\frac{7}{49}$	26	28			32	24	44
	21	$\frac{3}{21}$	28	28			32	24	44
289	49	$\frac{7}{49}$	26	56	24	24	72		24
	21	$\frac{3}{21}$	28	56	24	24	72		24
290	29	$\frac{4}{29}$	26						
291	15	$\frac{2}{15}$	25	40			48	44	
292	49	$\frac{7}{49}$	26	28			48	24	44
	21	$\frac{3}{21}$	28	28			48	24	44
293	15	$\frac{2}{15}$	25	48	32	40	56		
294	49	$\frac{7}{49}$	26	24			48	24	44
	21	$\frac{3}{21}$	28	24			48	24	44
295	15	$\frac{2}{15}$	25	48			32	44	
296	37	$\frac{5}{37}$	26						
297	33	$\frac{4}{33}$	23	28	48	24	56		
298	49	$\frac{7}{49}$	26	28			72	24	44
	21	$\frac{3}{21}$	28	28			72	24	44
299	23	$\frac{3}{23}$	25	24			24	56	
300	15	$\frac{2}{15}$	25						
301	43	$\frac{6}{43}$	26	24			48	24	44
302	16	$\frac{2}{16}$	24	32			72	24	
303	15	$\frac{2}{15}$	25	72	24	40	48		24
304	16	$\frac{2}{16}$	24	24			48	44	
305	15	$\frac{2}{15}$	25	48			32	24	44
306	15	$\frac{2}{15}$	25	40			32	24	44
307	15	$\frac{2}{15}$	25	72	48	40	56		24
308	16	$\frac{2}{16}$	24	32			48	44	
309	15	$\frac{2}{15}$	25	40			48	24	44
310	31	$\frac{4}{31}$	24						

INDEX TABLE 311 to 355

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
311	16	$\frac{2}{16}$	24	64	24	24	72		
312	39	$\frac{5}{39}$	24						
313	16	$\frac{2}{16}$	24	32			28	56	
314	16	$\frac{2}{16}$	24	32			24	56	
315	16	$\frac{2}{16}$	24	64			40	24	
316	16	$\frac{2}{16}$	24	64			32	44	
317	16	$\frac{2}{16}$	24	64			24	44	
318	16	$\frac{2}{16}$	24	56	28	48	24		
319	29	$\frac{4}{29}$	26	48	64	24	72		24
320	16	$\frac{2}{16}$	24						
321	16	$\frac{2}{16}$	24	72	24	64	24		24
322	23	$\frac{3}{23}$	25	32			64	24	44
323	16	$\frac{2}{16}$	24	64			24	24	44
324	16	$\frac{2}{16}$	24	64			32	24	44
325	16	$\frac{2}{16}$	24	64			40	24	44
326	16	$\frac{2}{16}$	24	32			24	24	44
327	16	$\frac{2}{16}$	24	32			28	24	44
328	41	$\frac{5}{41}$	23						
329	16	$\frac{2}{16}$	24	64	24	24	72		24
330	33	$\frac{4}{33}$	23						
331	16	$\frac{2}{16}$	24	64	44	24	48		24
332	16	$\frac{2}{16}$	24	32			48	24	44
333	27	$\frac{3}{27}$	21	24			72	44	
	18	$\frac{2}{18}$	21	24			72	44	
334	16	$\frac{2}{16}$	24	32			56	24	44
335	33	$\frac{4}{33}$	23	72	48	44	40		24
336	16	$\frac{2}{16}$	24	32			64	24	44
337	43	$\frac{5}{43}$	21	86	40	32	56		
338	16	$\frac{2}{16}$	24	32			72	24	44

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
339	27	$\frac{3}{27}$	21	24			56	44	
	18	$\frac{2}{18}$	21	24			56	44	
340	17	$\frac{2}{17}$	22						
341	43	$\frac{5}{43}$	21	86	24	32	40		
342	27	$\frac{3}{27}$	21	32			64	44	
	18	$\frac{2}{18}$	21	32			64	44	
343	15	$\frac{2}{15}$	25	40	64	24	86		24
344	43	$\frac{5}{43}$	21						
345	27	$\frac{3}{27}$	21	24			40	56	
	18	$\frac{2}{18}$	21	24			40	56	
346	27	$\frac{3}{27}$	21	72	56	32	64		
	18	$\frac{2}{18}$	21	72	56	32	64		
347	43	$\frac{5}{43}$	21	86	24	32	40		24
348	27	$\frac{3}{27}$	21	24			32	56	
	18	$\frac{2}{18}$	21	24			32	56	
349	27	$\frac{3}{27}$	21	72	44	24	48		
	18	$\frac{2}{18}$	21	72	44	24	48		
350	27	$\frac{3}{27}$	21	72	40	32	64		
	18	$\frac{2}{18}$	21	72	40	32	64		
351	27	$\frac{3}{27}$	21	24			24	56	
	18	$\frac{2}{18}$	21	24			24	56	
352	27	$\frac{3}{27}$	21	72	24	24	64		
	18	$\frac{2}{18}$	21	72	24	24	64		
353	27	$\frac{3}{27}$	21	72	24	24	56		
	18	$\frac{2}{18}$	21	72	24	24	56		
354	27	$\frac{3}{27}$	21	72			48	24	
	18	$\frac{2}{18}$	21	72			48	24	
355	27	$\frac{3}{27}$	21	72			40	24	
	18	$\frac{2}{18}$	21	72			40	24	

INDEX TABLE 356 TO 382

Number of Divisions	Index Circle	No. of Turns of Index	Graduation	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
356	27	3/27	21	72			32	24	
	18	2/18	21	72			32	24	
357	27	3/27	21	72			24	44	
	18	2/18	21	72			24	44	
358	27	3/27	21	72	32	48	24		
	18	2/18	21	72	32	48	24		
359	43	5/43	21	86	48	32	100		24
360	27	3/27	21						
	18	2/18	21						
361	19	2/19	19	32			64	44	
362	27	3/27	21	72	28	56	32		24
	18	2/18	21	72	28	56	32		24
363	27	3/27	21	72			24	24	44
	18	2/18	21	72			24	24	44
364	27	3/27	21	72			32	24	44
	18	2/18	21	72			32	24	44
365	20	2/20	18	32	48	24	56		
366	27	3/27	21	48			32	24	44
	18	2/18	21	48			32	24	44
367	27	3/27	21	72	24	24	56		24
	18	2/18	21	72	24	24	56		24
368	27	3/27	21	72	24	24	64		24
	18	2/18	21	72	24	24	64		24
369	41	4/41	18	32	56	28	64		
370	37	4/37	20						
371	21	2/21	18	32	56	24	64		
372	27	3/27	21	48			64	24	44
	18	2/18	21	48			64	24	44
373	20	2/20	18	40	48	32	72		
374	27	3/27	21	72	56	32	64		24
	18	2/18	21	72	56	32	64		24
375	27	3/27	21	24			40	24	44
	18	2/18	21	24			40	24	44
376	47	5/47	19						
377	29	3/29	19	24			24	56	
378	27	3/27	21	32			64	24	44
	18	2/18	21	32			64	24	44
379	20	2/20	18	48	56	40	72		
380	19	2/19	19						
381	27	3/27	21	24			56	24	44
	18	2/18	21	24			56	24	44
382	20	2/20	18	40			72	24	

INDEX TABLE

Plain and Differential Indexing for Divisions from 383 to 1008

Many of these divisions can be obtained by plain indexing and differential indexing, using the gears furnished with the machines. By the addition of eight special change gears all divisions from 383 to 1008 may be indexed.

The special change gears required have the following numbers of teeth: 46, 47, 52, 58, 68, 70, 76, 84.

INDEX TABLE 383 TO 488

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
383	20	2/20	40			68*	44		436	20	2/20	40	48	24	72		24
384	20	2/20	40			64	44		437	23	2/23	32			64	44	
385	20	2/20	32			48	44		438	21	2/21	28			48	24	44
386	20	2/20	40			56	44		439	43	4/43	86	24	24	72		24
387	43	4/43	32	56	28	64			440	33	8/33						
388	20	2/20	40			48	44		441	21	2/21	32			64	24	44
389	20	2/20	40			44	56		442	20	2/20	40	56	24	72		24
390	39	4/39							443	20	2/20	40	48	24	86		24
391	20	2/20	48	24	40	72			444	21	2/21	56	48	24	64		24
392	49	5/49							445	33	8/33	64	32	44	40		24
393	20	2/20	40			28	44		446	33	8/33	44			24	24	48
394	20	2/20	40			24	56		447	21	2/21	28			72	24	44
395	20	2/20	64			32	44		448	20	2/20	40	64	24	72		24
396	20	2/20	56	28	40	32			449	33	8/33	64	32	44	72		24
397	20	2/20	64	24	40	32			450	33	8/33	44			40	24	32
398	20	2/20	100	40	64	32			451	33	8/33	24			24	24	44
399	21	2/21	32			64	44		452	33	8/33	44			48	24	40
400	20	2/20							453	33	8/33	44			52*	24	40
401	21	2/21	56	32	24	76*			454	49	4/49	56	64	28	72		
402	21	2/21	28			48	44		455	49	4/49	28	40	32	64		
403	20	2/20	64	24	40	32		24	456	21	2/21	56	64	24	72		24
404	20	2/20	72	24	40	48		24	457	33	8/33	44			68*	24	40
405	20	2/20	64			32	24	44	458	33	8/33	44			72	24	24
406	20	2/20	40			24	24	44	459	27	2/27	24	48	24	72		
407	20	2/20	40			28	24	44	460	23	2/23						
408	20	2/20	40			32	24	44	461	33	8/33	44	28	24	72		24
409	20	2/20	40	24	32	48		24	462	33	8/33	32			64	24	44
410	41	4/41							463	21	2/21	56	64	24	86		24
411	21	2/21	28			24	56		464	33	8/33	44	48	28	56		24
412	20	2/20	40			48	24	44	465	33	8/33	44	24	24	100		24
413	21	2/21	48			32	44		466	49	4/49	56	48	28	64		
414	21	2/21	56			32	44		467	33	8/33	44	48	32	72		24
415	20	2/20	32			48	24	44	468	39	8/39	28	48	24	56		
416	20	2/20	40			64	24	44	469	49	4/49	28			48	44	
417	21	2/21	56	32	48	24			470	47	4/47						
418	20	2/20	40			72	24	44	471	49	4/49	56	32	28	76*		
419	33	8/33	44	28	24	72			472	49	4/49	56	32	28	72		
420	21	2/21							473	33	8/33	48	64	32	72		24
421	20	2/20	48	56	40	72		24	474	49	4/49	56	32	28	64		
422	20	2/20	40	44	32	64		24	475	49	4/49	56	40	28	48		
423	21	2/21	72	24	56	48		24	476	49	4/49	56			64	24	
424	43	4/43	86	24	24	48			477	27	2/27	24	48	24	56		
425	21	2/21	72	48	56	40		24	478	49	4/49	56	24	28	64		
426	21	2/21	56			32	24	44	479	49	4/49	56	32	28	44		
427	20	2/20	40	48	32	72		24	480	49	4/49	56	32	28	40		
428	20	2/20	40	56	32	64		24	481	37	8/37	24			24	56	
429	21	2/21	28			24	24	44	482	33	8/33	44	56	24	72		24
430	43	4/43							483	49	4/49	56			32	44	
431	21	2/21	72	44	28	48		24	484	49	4/49	56	24	28	32		
432	20	2/20	40	56	28	64		24	485	23	2/23	46*	24	24	100		24
433	20	2/20	40	44	24	72		24	486	27	2/27	32	56	28	64		
434	21	2/21	48			64	24	44	487	39	8/39	24	72	52*	44		
435	21	2/21	28			40	24	44	488	33	8/33	44	64	24	72		24

SPECIAL GEARS:
46, 47, 52, 58, 68, 70, 76, 84

* SPECIAL GEAR

INDEX TABLE 489 TO 594

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No.1 Hole: 1st Gear on Stud	No.1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No.1 Hole: 1st Gear on Stud	No.1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
489	23	$\frac{2}{23}$	46*	58*	32	64		24	542	39	$\frac{3}{39}$	52*	44	32	64		24
490	49	$\frac{4}{49}$							543	27	$\frac{2}{27}$	72	24	48	32		24
491	33	$\frac{3}{33}$	44	68*	24	72		24	544	15	$\frac{1}{15}$	40	56	24	64		
492	41	$\frac{3}{41}$	28	48	24	56			545	15	$\frac{1}{15}$	32	44	24	64		
493	29	$\frac{2}{29}$	32	64	24	72			546	39	$\frac{3}{39}$	32			64	24	44
494	39	$\frac{3}{39}$	32			64	44		547	27	$\frac{2}{27}$	72	32	48	56		24
495	27	$\frac{2}{27}$	32	40	24	64			548	27	$\frac{2}{27}$	72	32	48	64		24
496	49	$\frac{4}{49}$	56	24	28	32		24	549	27	$\frac{2}{27}$	72			48	24	24
497	49	$\frac{4}{49}$	56			32	24	44	550	15	$\frac{1}{15}$	32	40	24	64		
498	27	$\frac{2}{27}$	48	56	24	64			551	29	$\frac{2}{29}$	32			64	44	
499	49	$\frac{4}{49}$	56	24	28	48		24	552	27	$\frac{2}{27}$	72	24	24	64		24
500	49	$\frac{4}{49}$	56	32	28	40		24	553	49	$\frac{4}{49}$	28	48	24	72		24
501	49	$\frac{4}{49}$	56	32	28	44		24	554	27	$\frac{2}{27}$	72	56	48	64		24
502	49	$\frac{4}{49}$	56	32	28	48		24	555	15	$\frac{1}{15}$	24			72	44	
503	23	$\frac{2}{23}$	46*	64	32	86		24	556	15	$\frac{1}{15}$	24	44	40	64		
504	49	$\frac{4}{49}$	56			64	24	24	557	15	$\frac{1}{15}$	40	32	24	86		
505	49	$\frac{4}{49}$	56	40	28	48		24	558	27	$\frac{2}{27}$	48			64	24	44
506	49	$\frac{4}{49}$	56	32	28	64		24	559	39	$\frac{3}{39}$	24			72	24	44
507	39	$\frac{3}{39}$	24			24	56		560	43	$\frac{3}{43}$	86	40	32	64		
508	49	$\frac{4}{49}$	56	32	28	72		24	561	27	$\frac{2}{27}$	72	56	32	64		24
509	49	$\frac{4}{49}$	56	32	28	76*		24	562	27	$\frac{2}{27}$	72	44	24	64		24
510	49	$\frac{4}{49}$	56	40	28	64		24	563	29	$\frac{2}{29}$	58*			68*	44	
511	49	$\frac{4}{49}$	28			48	24	44	564	43	$\frac{3}{43}$	86	24	24	56		
512	49	$\frac{4}{49}$	56	44	28	64		24	565	15	$\frac{1}{15}$	24			56	44	
513	27	$\frac{2}{27}$	32			64	44		566	43	$\frac{3}{43}$	86	24	24	44		
514	49	$\frac{4}{49}$	56	48	28	64		24	567	15	$\frac{1}{15}$	32	44	40	64		
515	27	$\frac{2}{27}$	72	32	24	100			568	15	$\frac{1}{15}$	40	32	24	64		
516	43	$\frac{3}{43}$	32	56	28	64			569	29	$\frac{2}{29}$	58*			44	24	
517	49	$\frac{4}{49}$	56	48	28	72		24	570	15	$\frac{1}{15}$	32			64	44	
518	49	$\frac{4}{49}$	28			64	24	44	571	43	$\frac{3}{43}$	86	28	64	32		
519	27	$\frac{2}{27}$	72	56	32	64			572	15	$\frac{1}{15}$	40	28	24	64		
520	39	$\frac{3}{39}$							573	15	$\frac{1}{15}$	40			72	24	
521	27	$\frac{2}{27}$	72	76*	48	64			574	41	$\frac{3}{41}$	32			64	24	44
522	29	$\frac{2}{29}$	48	64	24	72			575	15	$\frac{1}{15}$	24			40	44	
523	27	$\frac{2}{27}$	72	68*	48	64			576	15	$\frac{1}{15}$	40			64	24	
524	27	$\frac{2}{27}$	72	32	24	64			577	43	$\frac{3}{43}$	86	32	64	44		24
525	27	$\frac{2}{27}$	72	40	32	64			578	15	$\frac{1}{15}$	48	44	40	64		
526	49	$\frac{4}{49}$	56	64	28	72		24	579	15	$\frac{1}{15}$	40			56	44	
527	31	$\frac{2}{31}$	32	64	24	72			580	29	$\frac{2}{29}$						
528	27	$\frac{2}{27}$	72	24	24	64			581	15	$\frac{1}{15}$	48	32	40	76*		
529	27	$\frac{2}{27}$	72	44	48	64			582	15	$\frac{1}{15}$	40			48	44	
530	15	$\frac{1}{15}$	24	56	32	64			583	27	$\frac{2}{27}$	72	64	24	86		24
531	27	$\frac{2}{27}$	72			48	24		584	15	$\frac{1}{15}$	48	32	40	64		
532	27	$\frac{2}{27}$	72	32	48	64			585	15	$\frac{1}{15}$	24			24	56	
533	27	$\frac{2}{27}$	72	32	48	56			586	15	$\frac{1}{15}$	72	48	40	56		
534	27	$\frac{2}{27}$	72			32	44		587	29	$\frac{2}{29}$	58*			28	24	44
535	27	$\frac{2}{27}$	72	32	48	40			588	15	$\frac{1}{15}$	40			32	44	
536	39	$\frac{3}{39}$	52*			64	24	44	589	15	$\frac{1}{15}$	72	44	40	48		
537	27	$\frac{2}{27}$	72	28	56	32			590	15	$\frac{1}{15}$	48			32	44	
538	29	$\frac{2}{29}$	58*	56	24	72			591	15	$\frac{1}{15}$	40			24	44	
539	49	$\frac{4}{49}$	28	48	24	56		24	592	16	$\frac{1}{16}$	24			72	44	
540	27	$\frac{2}{27}$							593	15	$\frac{1}{15}$	72	28	40	48		
541	39	$\frac{3}{39}$	52*	56	32	48		24	594	33	$\frac{2}{33}$	32	56	28	64		

SPECIAL GEARS:
46, 47, 52, 58, 68, 70, 76, 84

*SPECIAL GEAR

INDEX TABLE 595 TO 700

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No.1 Hole: 1st Gear on Stud	No.1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole	Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No.1 Hole: 1st Gear on Stud	No.1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
595	15	$\frac{1}{15}$	72			24	44		648	16	$\frac{1}{16}$	64			32	24	44
596	15	$\frac{1}{15}$	72	24	40	32			649	33	$\frac{2}{33}$	72			48	24	
597	33	$\frac{2}{33}$	44	56	24	72			650	16	$\frac{1}{16}$	64			40	24	44
598	16	$\frac{1}{16}$	64	56	24	72			651	16	$\frac{1}{16}$	64			44	24	24
599	43	$\frac{3}{43}$	86	44	24	84		24	652	16	$\frac{1}{16}$	32			24	24	44
600	15	$\frac{1}{15}$							653	33	$\frac{2}{33}$	72	28	44	48		
601	29	$\frac{2}{29}$	58*	56	48	72		24	654	16	$\frac{1}{16}$	64			56	24	44
602	43	$\frac{3}{43}$	32			64	24	44	655	16	$\frac{1}{16}$	64	40	32	48		24
603	15	$\frac{1}{15}$	72	24	40	24		24	656	16	$\frac{1}{16}$	24			24	24	44
604	16	$\frac{1}{16}$	32			72	24		657	18	$\frac{1}{18}$	32	48	24	56		
605	15	$\frac{1}{15}$	72			24	24	44	658	16	$\frac{1}{16}$	64	24	24	72		24
606	15	$\frac{1}{15}$	72	24	40	48		24	659	16	$\frac{1}{16}$	64	24	24	76*		24
607	15	$\frac{1}{15}$	72	28	40	48		24	660	33	$\frac{2}{33}$						
608	16	$\frac{1}{16}$	32			64	44		661	16	$\frac{1}{16}$	64	56	48	72		24
609	15	$\frac{1}{15}$	40			24	24	44	662	16	$\frac{1}{16}$	64	44	24	48		24
610	15	$\frac{1}{15}$	48			32	24	44	663	17	$\frac{1}{17}$	24			24	56	
611	15	$\frac{1}{15}$	72	44	40	48		24	664	16	$\frac{1}{16}$	32			48	24	44
612	15	$\frac{1}{15}$	40			32	24	44	665	49	$\frac{3}{49}$	56			40	24	44
613	16	$\frac{1}{16}$	64	48	32	72			666	18	$\frac{1}{18}$	24			72	44	
614	15	$\frac{1}{15}$	72	48	40	56		24	667	16	$\frac{1}{16}$	64	48	32	72		24
615	15	$\frac{1}{15}$	24			24	24	44	668	16	$\frac{1}{16}$	32			56	24	44
616	16	$\frac{1}{16}$	32			48	44		669	33	$\frac{2}{33}$	44			24	24	24
617	33	$\frac{2}{33}$	44	32	24	86			670	33	$\frac{2}{33}$	72	48	44	40		24
618	15	$\frac{1}{15}$	40			48	24	44	671	33	$\frac{2}{33}$	72			48	24	24
619	16	$\frac{1}{16}$	48	28	32	72			672	18	$\frac{1}{18}$	24			64	44	
620	31	$\frac{2}{31}$							673	16	$\frac{1}{16}$	48	44	32	72		24
621	15	$\frac{1}{15}$	40			56	24	44	674	33	$\frac{2}{33}$	72	56	44	48		24
622	16	$\frac{1}{16}$	64	24	24	72			675	33	$\frac{2}{33}$	44			40	24	24
623	16	$\frac{1}{16}$	64	24	24	68*			676	16	$\frac{1}{16}$	32			72	24	44
624	16	$\frac{1}{16}$	24			24	56		677	18	$\frac{1}{18}$	48	32	24	86		
625	15	$\frac{1}{15}$	24			40	24	44	678	18	$\frac{1}{18}$	24			56	44	
626	16	$\frac{1}{16}$	32			28	56		679	49	$\frac{3}{49}$	28			44	24	40
627	15	$\frac{1}{15}$	40			72	24	44	680	17	$\frac{1}{17}$						
628	16	$\frac{1}{16}$	32			24	56		681	33	$\frac{2}{33}$	44			56	24	24
629	16	$\frac{1}{16}$	64			44	24		682	33	$\frac{2}{33}$	48			64	24	24
630	16	$\frac{1}{16}$	64			40	24		683	16	$\frac{1}{16}$	32			86	24	44
631	16	$\frac{1}{16}$	64	28	56	72			684	18	$\frac{1}{18}$	32			64	44	
632	16	$\frac{1}{16}$	64			32	44		685	18	$\frac{1}{18}$	24	56	48	40		
633	16	$\frac{1}{16}$	64			28	44		686	15	$\frac{1}{15}$	40	64	24	86		24
634	16	$\frac{1}{16}$	64			24	44		687	18	$\frac{1}{18}$	24			44	48	
635	15	$\frac{1}{15}$	24			56	24	44	688	16	$\frac{1}{16}$	24			72	24	44
636	16	$\frac{1}{16}$	56	28	48	24			689	39	$\frac{2}{39}$	24	48	24	56		
637	49	$\frac{3}{49}$	24			24	56		690	18	$\frac{1}{18}$	24			40	56	
638	29	$\frac{2}{29}$	48	64	24	72		24	691	18	$\frac{1}{18}$	48	32	24	58*		
639	33	$\frac{2}{33}$	44	28	32	64			692	18	$\frac{1}{18}$	72	56	32	64		
640	16	$\frac{1}{16}$							693	18	$\frac{1}{18}$	32			48	44	
641	33	$\frac{2}{33}$	44	32	48	76*			694	17	$\frac{1}{17}$	68*			56	24	44
642	16	$\frac{1}{16}$	72	24	64	24		24	695	18	$\frac{1}{18}$	72	24	24	100		
643	16	$\frac{1}{16}$	64	28	56	24		24	696	18	$\frac{1}{18}$	24			32	56	
644	49	$\frac{3}{49}$	56			32	44		697	17	$\frac{1}{17}$	24			24	24	44
645	15	$\frac{1}{15}$	24			72	24	44	698	18	$\frac{1}{18}$	72	44	24	48		
646	16	$\frac{1}{16}$	64			24	24	44	699	18	$\frac{1}{18}$	48			56	44	
647	16	$\frac{1}{16}$	64			28	24	44	700	18	$\frac{1}{18}$	72	40	32	64		

SPECIAL GEARS:
46, 47, 52, 58, 68, 70, 76, 84

*SPECIAL GEAR

INDEX TABLE 701 TO 806

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole		Gear on Spindle	Idlers	
				1st Gear on Stud	2nd Gear on Stud		No. 1 Hole	No. 2 Hole
701	17	$\frac{1}{17}$	68*	48	32	56		24
702	18	$\frac{1}{18}$	24			24	56	
703	19	$\frac{1}{19}$	24			72	44	
704	18	$\frac{1}{18}$	72	24	24	64		
705	18	$\frac{1}{18}$	48			40	44	
706	18	$\frac{1}{18}$	72			56	24	
707	18	$\frac{1}{18}$	72			52*	24	
708	18	$\frac{1}{18}$	72			48	24	
709	18	$\frac{1}{18}$	72			44	24	
710	18	$\frac{1}{18}$	72			40	24	
711	18	$\frac{1}{18}$	64			32	44	
712	18	$\frac{1}{18}$	72			32	24	
713	18	$\frac{1}{18}$	72			28	44	
714	18	$\frac{1}{18}$	72			24	44	
715	18	$\frac{1}{18}$	72	32	64	40		
716	18	$\frac{1}{18}$	72	28	56	32		
717	18	$\frac{1}{18}$	72	24	64	32		
718	33	$\frac{2}{33}$	44	58*	24	64		24
719	17	$\frac{1}{17}$	68*	52*	24	72		24
720	18	$\frac{1}{18}$						
721	21	$\frac{1}{21}$	24	64	32	68*		
722	19	$\frac{1}{19}$	32			64	44	
723	18	$\frac{1}{18}$	72	24	64	32		24
724	18	$\frac{1}{18}$	72	28	56	32		24
725	18	$\frac{1}{18}$	72	24	48	40		24
726	18	$\frac{1}{18}$	72			24	24	44
727	18	$\frac{1}{18}$	72			28	24	44
728	18	$\frac{1}{18}$	72			32	24	44
729	18	$\frac{1}{18}$	64			32	24	44
730	20	$\frac{1}{20}$	32	48	24	56		
731	17	$\frac{1}{17}$	48	56	28	72		24
732	18	$\frac{1}{18}$	48			32	24	44
733	18	$\frac{1}{18}$	72			52	44	24
734	18	$\frac{1}{18}$	72			56	24	24
735	18	$\frac{1}{18}$	48			40	24	44
736	18	$\frac{1}{18}$	72	24	24	64		24
737	33	$\frac{2}{33}$	24	56	32	64		24
738	41	$\frac{2}{41}$	32	56	28	64		
739	18	$\frac{1}{18}$	72	24	24	76*		24
740	37	$\frac{2}{37}$						
741	18	$\frac{1}{18}$	48			56	24	44
742	21	$\frac{1}{21}$	32	56	24	64		
743	20	$\frac{1}{20}$	40	48	32	76*		
744	18	$\frac{1}{18}$	48			64	24	44
745	18	$\frac{1}{18}$	72	24	24	100		24
746	20	$\frac{1}{20}$	40	48	32	72		
747	18	$\frac{1}{18}$	32			48	24	44
748	18	$\frac{1}{18}$	72	64	32	56		24
749	19	$\frac{1}{19}$	76*			44		24
750	18	$\frac{1}{18}$	24			40	24	44
751	19	$\frac{1}{19}$	76*	24	32	48		
752	18	$\frac{1}{18}$	72	48	24	64		24
753	18	$\frac{1}{18}$	48	44	32	64		24

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole		Gear on Spindle	Idlers	
				1st Gear on Stud	2nd Gear on Stud		No. 1 Hole	No. 2 Hole
754	21	$\frac{1}{21}$	28	32	24	86		
755	20	$\frac{1}{20}$	32			72	44	
756	18	$\frac{1}{18}$	32			64	24	44
757	20	$\frac{1}{20}$	40			86		44
758	20	$\frac{1}{20}$	48	56	40	72		
759	33	$\frac{2}{33}$	24	48	24	72		24
760	19	$\frac{1}{19}$						
761	39	$\frac{2}{39}$	52*	32	48	76*		
762	18	$\frac{1}{18}$	24			56	24	44
763	21	$\frac{1}{21}$	24	44	24	48		
764	20	$\frac{1}{20}$	40			72	24	
765	18	$\frac{1}{18}$	48	40	24	72		24
766	20	$\frac{1}{20}$	40			68*		44
767	39	$\frac{2}{39}$	48			32	44	
768	20	$\frac{1}{20}$	40			64	44	
769	19	$\frac{1}{19}$	76*	32	64	72		24
770	20	$\frac{1}{20}$	32			48	44	
771	20	$\frac{1}{20}$	40			58*	44	
772	20	$\frac{1}{20}$	40			56	44	
773	20	$\frac{1}{20}$	40	24	32	72		
774	18	$\frac{1}{18}$	24			72	24	44
775	20	$\frac{1}{20}$	32			40	44	
776	20	$\frac{1}{20}$	40			48	44	
777	21	$\frac{1}{21}$	24			72	44	
778	20	$\frac{1}{20}$	40			44	56	
779	20	$\frac{1}{20}$	32	28	40	48		
780	39	$\frac{2}{39}$						
781	20	$\frac{1}{20}$	48	24	40	76*		
782	20	$\frac{1}{20}$	48	24	40	72		
783	20	$\frac{1}{20}$	48	24	40	68		
784	20	$\frac{1}{20}$	40			32	44	
785	20	$\frac{1}{20}$	32			24	56	
786	20	$\frac{1}{20}$	40			28	44	
787	20	$\frac{1}{20}$	48	24	40	52*		
788	20	$\frac{1}{20}$	40			24	56	
789	20	$\frac{1}{20}$	48	24	40	44		
790	20	$\frac{1}{20}$	48			24	44	
791	20	$\frac{1}{20}$	64	24	40	48		
792	20	$\frac{1}{20}$	56	28	40	32		
793	39	$\frac{2}{39}$	48			32	24	44
794	20	$\frac{1}{20}$	64	24	40	32		
795	20	$\frac{1}{20}$	64	32	56	28		
796	20	$\frac{1}{20}$	100	40	64	32		
797	20	$\frac{1}{20}$	100	24	64	40		
798	21	$\frac{1}{21}$	24			48	44	
799	39	$\frac{2}{39}$	52*	32	48	76*		24
800	20	$\frac{1}{20}$						
801	21	$\frac{1}{21}$	28			52*	44	
802	21	$\frac{1}{21}$	56	32	24	76*		
803	20	$\frac{1}{20}$	100	24	64	40		24
804	21	$\frac{1}{21}$	28			48	44	
805	20	$\frac{1}{20}$	64	32	56	28		24
806	20	$\frac{1}{20}$	64	24	40	32		24

SPECIAL GEARS:
46, 47, 52. 58. 68. 70, 76, 84

*SPECIAL GEAR

INDEX TABLE 807 TO 912

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole		Gear on Spindle	Idlers		Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole		Gear on Spindle	Idlers	
				1st Gear on Stud	2nd Gear on Stud		No. 1 Hole	No. 2 Hole					1st Gear on Stud	2nd Gear on Stud		No. 1 Hole	No. 2 Hole
807	20	$\frac{1}{20}$	64	32	40	28		24	860	43	$\frac{2}{43}$						
808	20	$\frac{1}{20}$	72	24	40	48		24	861	21	$\frac{1}{21}$	24			24	24	44
809	20	$\frac{1}{20}$	64	24	40	48		24	862	21	$\frac{1}{21}$	72	44	28	48		24
810	20	$\frac{1}{20}$	48			24	24	44	863	20	$\frac{1}{20}$	40	56	32	72		24
811	20	$\frac{1}{20}$	64	32	40	44		24	864	21	$\frac{1}{21}$	28			32	24	44
812	20	$\frac{1}{20}$	40			24	24	44	865	21	$\frac{1}{21}$	56	32	48	100		24
813	21	$\frac{1}{21}$	56	24	24	72			866	20	$\frac{1}{20}$	40	44	24	72		24
814	20	$\frac{1}{20}$	40			28	24	44	867	21	$\frac{1}{21}$	56	24	24	72		24
815	20	$\frac{1}{20}$	32			24	24	44	868	21	$\frac{1}{21}$	48			64	24	44
816	20	$\frac{1}{20}$	40			32	24	44	869	43	$\frac{2}{43}$	86	24	48	72		24
817	43	$\frac{2}{43}$	24			48	44		870	21	$\frac{1}{21}$	28			40	24	44
818	20	$\frac{1}{20}$	40	24	32	48		24	871	43	$\frac{2}{43}$	86	24	24	44		24
819	39	$\frac{2}{39}$	24			48	24	44	872	20	$\frac{1}{20}$	40	48	24	72		24
820	41	$\frac{2}{41}$							873	21	$\frac{1}{21}$	56	48	24	44		24
821	20	$\frac{1}{20}$	32	28	40	48		24	874	23	$\frac{1}{23}$	32			64	44	
822	21	$\frac{1}{21}$	28			24	56		875	43	$\frac{2}{43}$	86	40	48	72		24
823	39	$\frac{2}{39}$	52*	32	24	86		24	876	21	$\frac{1}{21}$	28			48	24	44
824	20	$\frac{1}{20}$	40			48	24	44	877	23	$\frac{1}{23}$	46*	24	24	86		
825	21	$\frac{1}{21}$	56			40	44		878	43	$\frac{2}{43}$	86	24	24	72		24
826	21	$\frac{1}{21}$	48			32	44		879	43	$\frac{2}{43}$	86	24	24	76*		24
827	20	$\frac{1}{20}$	40	24	32	72		24	880	43	$\frac{2}{43}$	32	64	86	40		24
828	21	$\frac{1}{21}$	56			32	44		881	43	$\frac{2}{43}$	86	48	32	56		24
829	21	$\frac{1}{21}$	72	24	28	44			882	21	$\frac{1}{21}$	24			48	24	44
830	20	$\frac{1}{20}$	32			48	24	44	883	21	$\frac{1}{21}$	48	32	28	86		24
831	21	$\frac{1}{21}$	56			24	44		884	20	$\frac{1}{20}$	40	56	24	72		24
832	20	$\frac{1}{20}$	40			64	24	44	885	43	$\frac{2}{43}$	86	24	24	100		24
833	20	$\frac{1}{20}$	40	44	32	48		24	886	20	$\frac{1}{20}$	40	48	24	86		24
834	21	$\frac{1}{21}$	56	32	48	24			887	43	$\frac{2}{43}$	86	48	32	72		24
835	20	$\frac{1}{20}$	32			56	24	44	888	21	$\frac{1}{21}$	56	48	24	64		24
836	20	$\frac{1}{20}$	40			72	24	44	889	21	$\frac{1}{21}$	24			56	24	44
837	21	$\frac{1}{21}$	72	24	56	24			890	43	$\frac{2}{43}$	86	40	24	72		24
838	43	$\frac{2}{43}$	86	44	24	48		†	891	23	$\frac{1}{23}$	46*			58*	44	
839	43	$\frac{2}{43}$	86	48	32	56			892	43	$\frac{2}{43}$	86	48	24	64		24
840	21	$\frac{1}{21}$							893	43	$\frac{2}{43}$	86	44	24	72		24
841	43	$\frac{2}{43}$	86	24	24	76*			894	21	$\frac{1}{21}$	28			72	24	44
842	20	$\frac{1}{20}$	48	56	40	72		24	895	43	$\frac{2}{43}$	86	56	40	100		24
843	21	$\frac{1}{21}$	72	24	56	24		24	896	20	$\frac{1}{20}$	40	64	24	72		24
844	20	$\frac{1}{20}$	40	44	32	64		24	897	23	$\frac{1}{23}$	24			24	56	
845	20	$\frac{1}{20}$	32			72	24	44	898	23	$\frac{1}{23}$	46*			44	56	
846	43	$\frac{2}{43}$	86	24	24	56			899	23	$\frac{1}{23}$	46*	28	32	48		
847	21	$\frac{1}{21}$	72			24	24	44	900	43	$\frac{2}{43}$	86	64	40	100		24
848	43	$\frac{2}{43}$	86	24	24	48			901	23	$\frac{1}{23}$	48	24	46*	76*		
849	21	$\frac{1}{21}$	56			24	24	44	902	43	$\frac{2}{43}$	86	56	24	72		24
850	21	$\frac{1}{21}$	72	48	56	40		24	903	43	$\frac{2}{43}$	24			48	24	44
851	21	$\frac{1}{21}$	72	24	28	44		24	904	47	$\frac{2}{47}$	47			72		24
852	21	$\frac{1}{21}$	56			32	24	44	905	43	$\frac{2}{43}$	86	72	40	100		24
853	43	$\frac{2}{43}$	86			28	24		906	47	$\frac{2}{47}$	47			68*		24
854	20	$\frac{1}{20}$	40	48	32	72		24	907	23	$\frac{1}{23}$	48	24	46*	52*		
855	21	$\frac{1}{21}$	56			40	24	44	908	49	$\frac{2}{49}$	56	64	28	72		
856	20	$\frac{1}{20}$	40	56	32	64		24	909	23	$\frac{1}{23}$	48	24	46*	44		
857	21	$\frac{1}{21}$	72	24	28	68*		24	910	49	$\frac{2}{49}$	28	40	32	64		
858	21	$\frac{1}{21}$	28			24	24	44	911	23	$\frac{1}{23}$	46*	48	64	24		
859	21	$\frac{1}{21}$	56	32	48	76*		24	912	21	$\frac{1}{21}$	56	64	24	72		24

SPECIAL GEARS:
46, 47, 52, 58, 68, 70, 76, 84

† BOLT FOR 1ST AND 2ND STUD GEARS IN NO. 2 HOLE
* SPECIAL GEAR

INDEX TABLE 913 TO 1008

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
913	23	$\frac{1}{23}$	48	24	46*	28		
914	23	$\frac{1}{23}$	48	24	46*	24		
915	21	$\frac{1}{21}$	56	48	24	100		24
916	21	$\frac{1}{21}$	28	32	24	76*		24
917	49	$\frac{2}{49}$	28			72	44	
918	21	$\frac{1}{21}$	28	64	32	52*		24
919	47	$\frac{2}{47}$	64	48	47*	56		
920	23	$\frac{1}{23}$						
921	21	$\frac{1}{21}$	32	48	28	72		24
922	49	$\frac{2}{49}$	56	58*	28	64		
923	49	$\frac{2}{49}$	56	48	28	76*		
924	49	$\frac{2}{49}$	28			64	44	
925	21	$\frac{1}{21}$	28	40	24	68*		24
926	21	$\frac{1}{21}$	56	64	24	86		24
927	23	$\frac{1}{23}$	48	24	46*	28		24
928	21	$\frac{1}{21}$	28	44	24	64		24
929	23	$\frac{1}{23}$	32	24	46*	24		24
930	49	$\frac{2}{49}$	56	32	28	100		
931	49	$\frac{2}{49}$	24			48	44	
932	49	$\frac{2}{49}$	56	48	28	64		
933	23	$\frac{1}{23}$	48	24	46*	52*		24
934	23	$\frac{1}{23}$	46*	24	24	28		24
935	49	$\frac{2}{49}$	56	40	28	72		
936	49	$\frac{2}{49}$	56	44	28	64		
937	49	$\frac{2}{49}$	56	32	28	86		
938	49	$\frac{2}{49}$	28			48	44	
939	21	$\frac{1}{21}$	28	44	24	72		24
940	47	$\frac{2}{47}$						
941	23	$\frac{1}{23}$	46*	28	32	48		24
942	49	$\frac{2}{49}$	56	32	28	76*		
943	23	$\frac{1}{23}$	24			24	24	48
944	49	$\frac{2}{49}$	56	32	28	72		
945	49	$\frac{2}{49}$	28			40	44	
946	49	$\frac{2}{49}$	56	32	28	68*		
947	49	$\frac{2}{49}$	56	44	28	48		
948	49	$\frac{2}{49}$	56	32	28	64		
949	23	$\frac{1}{23}$	46*	24	24	58*		24
950	49	$\frac{2}{49}$	56	40	28	48		
951	49	$\frac{2}{49}$	56	32	28	58*		
952	49	$\frac{2}{49}$	56			64	24	
953	49	$\frac{2}{49}$	56	24	28	72		
954	49	$\frac{2}{49}$	56	32	28	52*		
955	23	$\frac{1}{23}$	46*	40	32	56		24
956	49	$\frac{2}{49}$	56	24	28	64		
957	49	$\frac{2}{49}$	56	32	28	46*		
958	49	$\frac{2}{49}$	56	32	28	44		
959	49	$\frac{2}{49}$	28			24	56	
960	49	$\frac{2}{49}$	56	32	28	40		
961	47	$\frac{2}{47}$	47*	24	32	56		24
962	49	$\frac{2}{49}$	56	24	28	48		
963	23	$\frac{1}{23}$	46*	24	24	86		24
964	23	$\frac{1}{23}$	46*	44	24	48		24
965	49	$\frac{2}{49}$	56	24	28	40		

Number of Divisions	Index Circle	No. of Turns of Index	Gear on Worm	No. 1 Hole: 1st Gear on Stud	No. 1 Hole: 2nd Gear on Stud	Gear on Spindle	Idlers: No. 1 Hole	Idlers: No. 2 Hole
966	49	$\frac{2}{49}$	56			32	44	
967	23	$\frac{1}{23}$	46*	47*	24	48		24
968	49	$\frac{2}{49}$	56	24	28	32		
969	21	$\frac{1}{21}$	28	48	24	86		24
970	23	$\frac{1}{23}$	46*	24	24	100		24
971	23	$\frac{1}{23}$	46*	48	32	68*		24
972	27	$\frac{1}{27}$	32	56	28	64		
973	49	$\frac{2}{49}$	56	32	48	24		
974	23	$\frac{1}{23}$	46*	48	32	72		24
975	27	$\frac{1}{27}$	24	40	24	56		
976	23	$\frac{1}{23}$	46*	48	24	56		24
977	23	$\frac{1}{23}$	46*	48	32	76*		24
978	23	$\frac{1}{23}$	46*	58*	32	64		24
979	47	$\frac{2}{47}$	47*	48	32	52*		24
980	49	$\frac{2}{49}$						
981	27	$\frac{1}{27}$	24	44	24	48		
982	47	$\frac{2}{47}$	47*	48	32	56		24
983	23	$\frac{1}{23}$	46*	56	32	72		24
984	23	$\frac{1}{23}$	46*	48	24	64		24
985	23	$\frac{1}{23}$	46*	52*	40	100		24
986	29	$\frac{1}{29}$	32	64	24	72		
987	49	$\frac{2}{49}$	56	24	48	32		24
988	23	$\frac{1}{23}$	46*	48	24	68*		24
989	49	$\frac{2}{49}$	56	24	28	24		24
990	27	$\frac{1}{27}$	32	40	24	64		
991	49	$\frac{2}{49}$	70*	40	56	44		24
992	49	$\frac{2}{49}$	56	24	28	32		24
993	49	$\frac{2}{49}$	70*	40	56	52*		24
994	49	$\frac{2}{49}$	56			32	24	44
995	49	$\frac{2}{49}$	56	24	28	40		24
996	27	$\frac{1}{27}$	48	56	24	64		
997	49	$\frac{2}{49}$	70*	40	56	68*		24
998	49	$\frac{2}{49}$	56	24	28	48		24
999	27	$\frac{1}{27}$	24			72	44	
1000	49	$\frac{2}{49}$	56	32	28	40		24
1001	49	$\frac{2}{49}$	28			24	24	44
1002	49	$\frac{2}{49}$	56	32	28	44		24
1003	49	$\frac{2}{49}$	56	32	28	46*		24
1004	49	$\frac{2}{49}$	56	32	28	48		24
1005	27	$\frac{1}{27}$	72	48	24	100		
1006	23	$\frac{1}{23}$	46*	64	32	86		24
1007	49	$\frac{2}{49}$	56	24	28	72		24
1008	49	$\frac{2}{49}$	56			64	24	24

Special Gears:
46, 47, 52, 58, 68, 70, 76, 84

*Special Gear

TABLE OF APPROXIMATE ANGLES FOR CUTTING SPIRALS

$$\text{TANGENT OF ANGLE OF SPIRAL} = \frac{\text{CIRCUMFERENCE OF CUTTER, DRILL, OR MILL}}{\text{LEAD IN INCHES TO ONE TURN}}$$

C = CIRCUMFERENCE OF CUTTER, DRILL, OR MILL
L = LEAD IN INCHES TO ONE TURN
T = TANGENT OF ANGLE OF SPIRAL

$T = \frac{C}{L}$ $L = \frac{C}{T}$

NOS. OF TEETH IN GEARS FURNISHED WITH MACHINE
24(2) 28 32 40 44 48 56 64 72 86 100

$$\text{THE LEAD IN INCHES TO ONE TURN} = \frac{10 \times \text{GEAR ON WORM} \times \text{2ND GEAR ON STUD}}{\text{GEAR ON SCREW} \times \text{1ST GEAR ON STUD}}$$

DIAMETER OF CUTTER, DRILL, OR MILL

Gear on Worm	1st Gear on Stud	2nd Gear on Stud	Gear on Screw	Lead in Inches to One Turn	⅛"	¼"	⅜"	½"	⅝"	¾"	⅞"	1"	1¼"	1½"	1¾"	2"	2¼"	2½"	2¾"	3"	3¼"	3½"	3¾"	4"	4¼"	4½"	4¾"	5"	5¼"	5½"	5¾"	6"
24	72	28	86	1.085	20	36	47¼																									
24	72	32	86	1.240	17½	32¼	43½	51¾																								
24	72	40	100	1.333	16½	30½	41½	49¾																								
24	48	28	100	1.400	15¾	29¼	40	48¼																								
24	64	40	100	1.500	14¾	27¾	38¼	46¼	52½																							
28	56	32	100	1.600	13¾	26¼	36¼	44½	50¾																							
24	72	44	86	1.706	13	24¾	34½	42½	49																							
24	64	48	100	1.800	12¼	23½	33¼	41	47½	52½																						
24	40	32	100	1.920	11½	22¼	31½	39¼	45¾	50¾																						
28	64	40	86	2.035	11	21	30	37¾	44	49¼																						
24	72	56	86	2.171	10¼	20	28½	35¾	42	47¼	51¾																					
24	64	44	72	2.292	9¾	19	27¼	34½	40½	45¾	50¼																					
28	64	56	100	2.450	9	17¾	25¾	32¾	38¾	44	48¼	52																				
40	86	56	100	2.605	8½	16¾	24¼	31	37	42	46½	50¼																				
40	56	28	72	2.778	8	15¾	23	29½	35¼	40¼	44¾	48½																				
24	56	44	64	2.946	7½	15	21¾	28	33¾	38¾	43	46¾																				
24	86	72	64	3.140	7	14	20½	26½	32	37	41¼	45	51¼																			
28	56	48	72	3.333	6¾	13¼	19½	25¼	30½	35¼	39½	43¼	49¾																			
48	44	28	86	3.552	6¼	12½	18¼	23¾	29	33½	37¾	41½	47¾	53																		
44	56	48	100	3.771	6	11¾	17¼	22½	27½	32	36	39¾	46¼	51¼																		
72	100	48	86	4.019	5½	11	16¼	21¼	26	30½	34¼	38	44¼	49½																		
64	48	32	100	4.267	5¼	10½	15½	20¼	24¾	29	32¾	36¼	42½	47¾	52¼																	
56	48	28	72	4.537	5	9¾	14½	19	23½	27½	31¼	34¾	41	46	50½																	
56	64	40	72	4.861	4½	9¼	13½	18	22	25¾	29½	32¾	39	44	48½	52¼																

EXAMPLE ILLUSTRATING USE OF TABLE

DIAMETER OF CUTTER, DRILL, OR MILL........... = 1¼
LEAD IN INCHES TO ONE TURN.................... = 3.140
REQUIRED ANGLE TO NEAREST QUARTER DEGREE
TO SET SADDLE OF UNIVERSAL MILLING MACHINE = 51¼°

TABLE OF APPROXIMATE ANGLES FOR CUTTING SPIRALS

$$\text{TANGENT OF ANGLE OF SPIRAL} = \frac{\text{CIRCUMFERENCE OF CUTTER, DRILL, OR MILL}}{\text{LEAD IN INCHES TO ONE TURN}}$$

C = CIRCUMFERENCE OF CUTTER, DRILL, OR MILL
L = LEAD IN INCHES TO ONE TURN
T = TANGENT OF ANGLE OF SPIRAL

$$T = \frac{C}{L} \qquad L = \frac{C}{T}$$

NOS. OF TEETH IN GEARS FURNISHED WITH MACHINE
24(2) 28 32 40 44 48 56 64 72 86 100

$$\text{THE LEAD IN INCHES TO ONE TURN} = \frac{10 \times \text{GEAR ON WORM} \times \text{2ND GEAR ON STUD}}{\text{GEAR ON SCREW} \times \text{1ST GEAR ON STUD}}$$

DIAMETER OF CUTTER, DRILL, OR MILL

Gear on Worm	1st Gear on Stud	2nd Gear on Stud	Gear on Screw	Lead in Inches to One Turn	⅛″	¼″	⅜″	½″	⅝″	¾″	⅞″	1″	1¼″	1½″	1¾″	2″
56	48	44	100	5.133	4¼	8¾	13	17	21	24¾	28¼	31½	37½	42½	47	50¾
86	44	28	100	5.473	4	8¼	12¼	16	19¾	23¼	26¾	29¾	35¾	40¾	45	49
100	48	24	86	5.814	3¾	7¾	11½	15	18¾	22	25¼	28½	34	39	43½	47¼
72	56	48	100	6.171	3¾	7¼	10¾	14¼	17¾	21	24	27	32½	37¼	41¾	45½
72	56	44	86	6.578	3½	6¾	10¼	13½	16½	19¾	22¾	25½	30¾	35½	40	43¾
56	32	40	100	7.000	3¼	6½	9½	12¾	15¾	18½	21½	24¼	29¼	34	38¼	42
56	28	32	86	7.442	3	6	9	12	14¾	17½	20¼	23	27¾	32¼	36½	40¼
72	40	44	100	7.920	2¾	5¾	8½	11¼	14	16½	19¼	21¾	26¼	30¾	34¾	38½
56	32	48	100	8.400	2¾	5¼	8	10½	13¼	15¾	18	20½	25	29¼	33¼	36¾
86	32	24	72	8.959	2½	5	7½	10	12¼	14¾	17	19¼	23¾	27¾	31½	35
64	48	40	56	9.524	2¼	4¾	7	9¼	11¾	14	16	18¼	22½	26¼	30	33½
100	44	32	72	10.101	2¼	4½	6¾	8¾	11	13	15¼	17½	21¼	25	28½	31¾
86	40	32	64	10.750	2	4¼	6¼	8¼	10¼	12¼	14¼	16¼	20	23¾	27	30¼
86	48	64	100	11.467	2	4	5¾	7¾	9¾	11½	13½	15¼	19	22¼	25½	28¾
72	44	64	86	12.178	1¾	3¾	5½	7¼	9¼	11	12¾	14½	18	21¼	24¼	27¼
56	24	40	72	12.963	1¾	3½	5¼	7	8½	10¼	12	13½	16¾	20	23	25¾
86	40	64	100	13.760	1¾	3¼	5	6½	8	9¾	11¼	12¾	16	19	21¾	24½
86	44	48	64	14.659	1½	3	4½	6	7¾	9¼	10½	12	15	17¾	20½	23¼
64	32	56	72	15.556	1½	3	4¼	5¾	7¼	8½	10	11½	14¼	16¾	19½	22
72	40	44	48	16.500	1¼	2¾	4	5½	6¾	8¼	9½	10¾	13½	16	18½	20¾
100	44	56	72	17.677	1¼	2½	3¾	5	6¼	7½	8¾	10	12½	15	17¼	19½
86	28	44	72	18.770	1¼	2½	3½	4¾	6	7¼	8¼	9½	11¾	14	16¼	18½
100	28	48	86	19.934	1¼	2¼	3½	4½	5½	6¾	7¾	9	11¼	13¼	15½	17½
86	32	44	56	21.12	1	2¼	3¼	4¼	5¼	6¼	7½	8½	10½	12½	14½	16½

Gear on Worm	1st Gear on Stud	2nd Gear on Stud	Gear on Screw	Lead in Inches to One Turn	2¼″	2½″	2¾″	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	5″	5¼″	5½″	5¾″	6″
56	48	44	100	5.133																
86	44	28	100	5.473	52¼															
100	48	24	86	5.814	50½															
72	56	48	100	6.171	48¾	51¾														
72	56	44	86	6.578	47	50	52¾													
56	32	40	100	7.000	45¼	48¼	51													
56	28	32	86	7.442	43½	46½	49¼	51¾												
72	40	44	100	7.920	41¾	44¾	47½	50	52¼											
56	32	48	100	8.400	40	43	45¾	48¼	50½	52½										
86	32	24	72	8.959	38¼	41¼	44	46½	48¾	50¾	52¾									
64	48	40	56	9.524	36½	39½	42¼	44¾	47	49	51	52¾								
100	44	32	72	10.101	35	37¾	40½	43	45¼	47½	49½	51¼	53							
86	40	32	64	10.750	33¼	36¼	38¾	41¼	43½	45¾	47½	49½	51¼	52¾						
86	48	64	100	11.467	31¾	34½	37	39½	41¾	43¾	45¾	47½	49¼	51	52½					
72	44	64	86	12.178	30¼	32¾	35¼	37¾	40	42	44	46	47¾	49¼	50¾	52¼				
56	24	40	72	12.963	28½	31¼	33¾	36	38¼	40¼	42¼	44	45¾	47½	49	50½	51½	51¾		
86	40	64	100	13.760	27¼	29¾	32	34½	36½	38½	40½	42½	44¼	45¾	47¼	48¾	50¼	51½	52¾	
86	44	48	64	14.659	25¾	28¼	30½	32¾	34¾	36¾	38¾	40½	42¼	44	45½	47	48¼	49¾	51	52
64	32	56	72	15.556	24½	26¾	29	31¼	33¼	35¼	37¼	39	40¾	42¼	43¾	45¼	46¾	48	49¼	50½
72	40	44	48	16.500	23¼	25½	27¾	29¾	31¾	33¾	35½	37¼	39	40½	42	43½	45	46¼	47½	48¾
100	44	56	72	17.677	21¾	24	26	28	30	31¾	33¾	35½	37	38¾	40¼	41½	43	44¼	45½	46¾
86	28	44	72	18.770	20¾	22¾	24¾	26¾	28½	30¼	32	33¾	35½	37	38½	40	41¼	42½	44	45
100	28	48	86	19.934	19½	21½	23½	25¼	27	28¾	30½	32¼	33¾	35¼	36¾	38¼	39½	41	42¼	43½
86	32	44	56	21.12	18½	20½	22¼	24	25¾	27½	29¼	30¾	32¼	33¾	35¼	36¾	38	39¼	40½	41¾

TABLE OF APPROXIMATE ANGLES FOR CUTTING SPIRALS

$$\text{TANGENT OF ANGLE OF SPIRAL} = \frac{\text{CIRCUMFERENCE OF CUTTER, DRILL, OR MILL}}{\text{LEAD IN INCHES TO ONE TURN}}$$

C = CIRCUMFERENCE OF CUTTER, DRILL, OR MILL
L = LEAD IN INCHES TO ONE TURN
T = TANGENT OF ANGLE OF SPIRAL

$T = \frac{C}{L}$ $L = \frac{C}{T}$

NOS. OF TEETH IN GEARS FURNISHED WITH MACHINE
24(2) 28 32 40 44 48 56 64 72 86 100

$$\text{THE LEAD IN INCHES TO ONE TURN} = \frac{10 \times \text{GEAR ON WORM} \times \text{2ND GEAR ON STUD}}{\text{GEAR ON SCREW} \times \text{1ST GEAR ON STUD}}$$

Gear on Worm	1st Gear on Stud	2nd Gear on Stud	Gear on Screw	Lead in Inches to One Turn	Diameter of Cutter, Drill, or Mill																											
					1/8″	1/4″	3/8″	1/2″	5/8″	3/4″	7/8″	1″	1 1/4″	1 1/2″	1 3/4″	2″	2 1/4″	2 1/2″	2 3/4″	3″	3 1/4″	3 1/2″	3 3/4″	4″	4 1/4″	4 1/2″	4 3/4″	5″	5 1/4″	5 1/2″	5 3/4″	6″
72	28	56	64	22.50	1	2	3	4	5	6	7	8	10	11 3/4	13 3/4	15 1/2	17 1/2	19 1/4	21	22 3/4	24 1/2	26	27 3/4	29 1/4	30 3/4	32 1/4	33 1/2	35	36 1/4	37 1/2	38 3/4	40
64	40	72	48	24.00	1	2	2 3/4	3 3/4	4 3/4	5 1/2	6 1/2	7 1/2	9 1/4	11	13	14 3/4	16 1/2	18 1/4	19 3/4	21 1/2	23	24 1/2	26 1/4	27 1/2	29	30 1/2	31 3/4	33 1/4	34 1/2	35 3/4	37	38 1/4
100	64	72	44	25.57	1	1 3/4	2 3/4	3 1/2	4 1/2	5 1/4	6 1/4	7 1/4	8 3/4	10 1/2	12 1/4	13 3/4	15 1/2	17	18 3/4	20 1/4	21 3/4	23 1/4	24 3/4	26 1/4	27 1/2	29	30 1/4	31 1/2	32 3/4	34	35 1/4	36 1/2
100	72	86	44	27.15		1 3/4	2 1/2	3 1/4	4 1/4	5	5 3/4	6 1/2	8 1/4	9 3/4	11 1/2	13	14 1/2	16 1/4	17 3/4	19 1/4	20 1/2	22	23 1/2	24 3/4	26 1/4	27 1/2	28 3/4	30	31 1/4	32 1/2	33 3/4	34 3/4
86	40	64	48	28.67		1 1/2	2 1/4	3 1/4	4	4 3/4	5 1/2	6 1/4	7 3/4	9 1/4	10 3/4	12 1/4	13 3/4	15 1/4	16 3/4	18 1/4	19 1/2	21	22 1/4	23 3/4	25	26 1/4	27 1/2	28 3/4	30	31	32 1/4	33 1/4
86	32	64	56	30.71		1 1/2	2 1/4	3	3 3/4	4 1/2	5	5 3/4	7 1/4	8 3/4	10 1/4	11 1/2	13	14 1/4	15 3/4	17	18 1/2	19 3/4	21	22 1/4	23 1/2	24 3/4	26	27	28 1/4	29 1/4	30 1/2	31 1/2
72	32	64	44	32.73		1 1/4	2	2 3/4	3 1/2	4	4 3/4	5 1/2	6 3/4	8 1/4	9 1/2	10 3/4	12 1/4	13 1/2	14 3/4	16	17 1/4	18 1/2	19 3/4	21	22 1/4	23 1/4	24 1/2	25 3/4	26 3/4	27 3/4	29	30
100	24	40	48	34.72		1 1/4	2	2 1/2	3 1/4	4	4 1/2	5 1/4	6 1/2	7 3/4	9	10 1/4	11 1/2	12 3/4	14	15 1/4	16 1/2	17 1/2	18 3/4	20	21	22 1/4	23 1/4	24 1/4	25 1/2	26 1/2	27 1/2	28 1/2
100	24	64	72	37.04		1 1/4	1 3/4	2 1/2	3	3 3/4	4 1/4	4 3/4	6	7 1/4	8 1/2	9 3/4	10 3/4	12	13 1/4	14 1/4	15 1/2	16 1/2	17 3/4	18 3/4	19 3/4	21	22	23	24	25	26	27
100	28	44	40	39.29		1 1/4	1 3/4	2 1/4	2 3/4	3 1/2	4	4 1/2	5 3/4	6 3/4	8	9	10 1/4	11 1/4	12 1/2	13 1/2	14 1/2	15 3/4	16 3/4	17 3/4	18 3/4	19 3/4	20 3/4	21 3/4	22 3/4	23 3/4	24 3/4	25 1/2
86	24	56	48	41.81		1	1 1/2	2 1/4	2 3/4	3 1/4	3 3/4	4 1/4	5 1/4	6 1/2	7 1/2	8 1/2	9 1/2	10 3/4	11 3/4	12 3/4	13 3/4	14 3/4	15 3/4	16 3/4	17 3/4	18 3/4	19 3/4	20 1/2	21 1/2	22 1/2	23 1/4	24 1/4
100	28	40	32	44.64		1	1 1/2	2	2 1/2	3	3 1/2	4	5	6	7	8	9	10	11	12	13	13 3/4	14 3/4	15 3/4	16 3/4	17 1/2	18 1/2	19 1/2	20 1/4	21 1/4	22	23
100	28	64	48	47.62		1	1 1/2	2	2 1/4	2 3/4	3 1/4	3 3/4	4 3/4	5 3/4	6 1/2	7 1/2	8 1/2	9 1/4	10 1/4	11 1/4	12	13	14	14 3/4	15 3/4	16 1/2	17 1/2	18 1/4	19	20	20 3/4	21 1/2
86	28	72	44	50.26		1	1 1/4	1 3/4	2 1/4	2 3/4	3 1/4	3 1/2	4 1/2	5 1/4	6 1/4	7 1/4	8	9	9 3/4	10 1/2	11 1/2	12 1/4	13 1/4	14	14 3/4	15 3/4	16 1/2	17 1/4	18 1/4	19	19 3/4	20 1/2
100	28	48	32	53.57			1 1/4	1 3/4	2	2 1/2	3	3 1/4	4 1/2	5	5 3/4	6 3/4	7	8 1/4	9 1/4	10	10 3/4	11 1/2	12 1/2	13 1/4	14	14 3/4	15 1/2	16 1/4	17	17 3/4	18 3/4	19 1/2
100	28	64	40	57.14			1 1/4	1 1/2	2	2 1/4	2 3/4	3 1/4	4	4 3/4	5 1/2	6 1/4	7	7 3/4	8 1/2	9 1/4	10 1/4	11	11 3/4	12 1/2	13 1/4	14	14 3/4	15 1/4	16	16 3/4	17 1/2	18 1/4
100	24	64	44	60.61			1	1 1/2	1 3/4	2 1/4	2 1/2	3	3 3/4	4 1/2	5 1/4	6	6 3/4	7 1/2	8	8 3/4	9 1/2	10 1/4	11	11 3/4	12 1/2	13	13 3/4	14 1/2	15 1/4	16	16 1/2	17 1/4
100	28	86	48	63.99				1 1/2	1 3/4	2	2 1/2	2 3/4	3 1/2	4 1/4	5	5 1/2	6 1/4	7	7 3/4	8 1/2	9	9 3/4	10 1/2	11	11 3/4	12 1/2	13	13 3/4	14 1/2	15	15 3/4	16 1/2
72	24	64	28	68.57				1 1/4	1 3/4	2	2 1/4	2 1/2	3 1/4	4	4 1/2	5 1/4	6	6 1/2	7 1/4	7 3/4	8 1/2	9	9 3/4	10 1/2	11	11 3/4	12 1/4	13	13 1/2	14 1/4	14 3/4	15 1/4
86	24	64	32	71.67				1 1/4	1 1/2	2	2 1/4	2 1/2	3 1/4	3 3/4	4 1/2	5	5 3/4	6 1/4	6 3/4	7 1/2	8	8 3/4	9 1/4	10	10 1/2	11 1/4	11 3/4	12 1/4	13	13 1/2	14 1/4	14 3/4
100	24	72	40	75.00				1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4 1/4	4 3/4	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	9	9 1/2	10	10 3/4	11 1/4	11 3/4	12 1/2	13	13 1/2	14
100	24	64	32	83.33				1	1 1/4	1 1/2	2	2 1/4	2 3/4	3 1/4	3 3/4	4 1/4	4 3/4	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4
100	24	86	40	89.59				1	1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	10 1/2	11	11 1/2	12
100	24	64	28	95.24					1 1/4	1 1/2	1 3/4	2	2 1/4	2 3/4	3 1/4	3 3/4	4 1/4	4 3/4	5 1/4	5 3/4	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4

TABLE OF LEADS

This table contains all the leads that can be obtained with any possible combination of the change gears furnished with Universal Milling Machines made by Brown & Sharpe Mfg. Co., even though some of the leads are not available for use on account of the gears interfering or not reaching. Combinations of gears that are too small in diameter to reach for right-hand spirals can generally be used for left-hand spirals, as the reverse gear is then required and will enable the gears to reach. For further information regarding the use of these tables, see Chapter IV.

TABLE OF LEADS, .670″ TO 2.182″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
.670	24	86	24	100	1.527	24	44	28	100	1.886	24	56	44	100
.781	24	86	28	100	1.550	24	72	40	86	1.905	24	56	32	72
.800	24	72	24	100	1.556	28	72	40	100	1.919	24	64	44	86
.893	24	86	32	100	1.563	24	86	56	100	1.920	24	40	32	100
.900	24	64	24	100	1.563	28	86	48	100	1.925	28	64	44	100
.930	24	72	24	86	1.595	24	56	32	86	1.944	24	48	28	72
.933	24	72	28	100	1.600	24	48	32	100	1.944	28	64	32	72
1.029	24	56	24	100	1.600	28	56	32	100	1.954	24	40	28	86
1.042	28	86	32	100	1.600	24	72	48	100	1.956	32	72	44	100
1.047	24	64	24	86	1.607	24	56	24	64	1.990	28	72	44	86
1.050	24	64	28	100	1.628	24	48	28	86	1.993	24	56	40	86
1.067	24	72	32	100	1.628	28	64	32	86	2.000	24	40	24	72
1.085	24	72	28	86	1.637	32	86	44	100	2.000	24	48	40	100
1.116	24	86	40	100	1.650	24	64	44	100	2.000	28	56	40	100
1.196	24	56	24	86	1.667	24	56	28	72	2.000	32	64	40	100
1.200	24	48	24	100	1.667	24	48	24	72	2.009	24	86	72	100
1.200	24	56	28	100	1.667	24	64	32	72	2.030	24	44	32	86
1.200	24	64	32	100	1.674	24	40	24	86	2.035	28	64	40	86
1.221	24	64	28	86	1.680	24	40	28	100	2.036	28	44	32	100
1.228	24	86	44	100	1.706	24	72	44	86	2.045	24	44	24	64
1.240	24	72	32	86	1.711	28	72	44	100	2.047	40	86	44	100
1.244	28	72	32	100	1.714	24	56	40	100	2.057	24	28	24	100
1.250	24	64	24	72	1.744	24	64	40	86	2.057	24	56	48	100
1.302	28	86	40	100	1.745	24	44	32	100	2.067	32	72	40	86
1.309	24	44	24	100	1.750	28	64	40	100	2.083	24	64	40	72
1.333	24	72	40	100	1.776	24	44	28	86	2.084	28	86	64	100
1.340	24	86	48	100	1.778	32	72	40	100	2.084	32	86	56	100
1.371	24	56	32	100	1.786	24	86	64	100	2.093	24	64	48	86
1.395	24	48	24	86	1.786	32	86	48	100	2.093	24	32	24	86
1.395	24	56	28	86	1.800	24	64	48	100	2.100	24	64	56	100
1.395	24	64	32	86	1.800	24	32	24	100	2.100	28	64	48	100
1.400	24	48	28	100	1.809	28	72	40	86	2.100	24	32	28	100
1.400	28	64	32	100	1.818	24	44	24	72	2.121	24	44	28	72
1.429	24	56	24	72	1.823	28	86	56	100	2 133	24	72	64	100
1.433	28	86	44	100	1.860	28	56	32	86	2.133	32	72	48	100
1.440	24	40	24	100	1.861	24	72	48	86	2.143	24	56	32	64
1.447	28	72	32	86	1.861	24	48	32	86	2.143	24	48	24	56
1.458	24	64	28	72	1.867	28	48	32	100	2.171	24	72	56	86
1.467	24	72	44	100	1.867	24	72	56	100	2.171	28	48	32	86
1.488	32	86	40	100	1.867	28	72	48	100	2.171	28	72	48	86
1.500	24	64	40	100	1.875	24	48	24	64	2.178	28	72	56	100
1.522	24	44	24	86	1.875	24	56	28	64	2.182	24	44	40	100

TABLE OF LEADS, 2.188″ TO 3.080″

Lead in Inches	Driven Gear on Worm	Driver 1st Gear on Stud	Driven 2nd Gear on Stud	Driver Gear on Screw	Lead in Inches	Driven Gear on Worm	Driver 1st Gear on Stud	Driven 2nd Gear on Stud	Driver Gear on Screw	Lead in Inches	Driven Gear on Worm	Driver 1st Gear on Stud	Driven 2nd Gear on Stud	Driver Gear on Screw
2.188	24	48	28	64	2.500	24	48	28	56	2.800	24	24	28	100
2.193	24	56	44	86	2.500	28	56	32	64	2.800	32	64	56	100
2.200	24	48	44	100	2.500	24	64	48	72	2.800	24	48	56	100
2.200	28	56	44	100	2.500	24	48	32	64	2.812	24	32	24	64
2.200	32	64	44	100	2.500	24	32	24	72	2.828	28	44	32	72
2.222	24	48	32	72	2.514	32	56	44	100	2.843	40	72	44	86
2.222	28	56	32	72	2.532	28	72	56	86	2.845	32	72	64	100
2.233	40	86	48	100	2.537	24	44	40	86	2.849	28	64	56	86
2.233	24	40	32	86	2.546	28	44	40	100	2.857	24	48	32	56
2.238	28	64	44	86	2.558	32	64	44	86	2.857	24	56	48	72
2.240	28	40	32	100	2.558	28	56	44	86	2.857	24	28	24	72
2.250	24	40	24	64	2.558	24	48	44	86	2.865	44	86	56	100
2.274	32	72	44	86	2.567	28	48	44	100	2.867	86	72	24	100
2.286	32	56	40	100	2.571	24	40	24	56	2.880	24	40	48	100
2.292	24	64	44	72	2.593	28	48	32	72	2.894	28	72	64	86
2.326	32	64	40	86	2.605	28	40	32	86	2.894	32	72	56	86
2.326	24	48	40	86	2.605	40	86	56	100	2.909	32	44	40	100
2.326	28	56	40	86	2.618	24	44	48	100	2.917	24	64	56	72
2.333	28	48	40	100	2.619	24	56	44	72	2.917	28	64	48	72
2.333	24	40	28	72	2.625	24	40	28	64	2.917	28	48	32	64
2.338	24	44	24	56	2.640	24	40	44	100	2.917	24	32	28	72
2.344	28	86	72	100	2.658	32	56	40	86	2.924	32	56	44	86
2.368	28	44	32	86	2.667	40	72	48	100	2.933	44	72	48	100
2.381	32	86	64	100	2.667	32	48	40	100	2.934	32	48	44	100
2.381	24	56	40	72	2.667	24	40	32	72	2.946	24	56	44	64
2.386	24	44	28	64	2.674	28	64	44	72	2.950	28	44	40	86
2.392	24	56	48	86	2.678	24	56	40	64	2.977	40	86	64	100
2.392	24	28	24	86	2.679	32	86	72	100	2.984	28	48	44	86
2.400	28	56	48	100	2.700	24	64	72	100	3.000	24	40	28	56
2.400	32	64	48	100	2.713	28	48	40	86	3.000	24	40	32	64
2.424	24	44	32	72	2.727	24	44	32	64	3.000	24	32	40	100
2.431	28	64	40	72	2.727	24	44	28	56	3.000	40	64	48	100
2.442	24	32	28	86	2.727	24	44	24	48	3.000	24	40	24	48
2.442	28	64	48	86	2.743	24	56	64	100	3.030	24	44	40	72
2.442	24	64	56	86	2.743	32	56	48	100	3.044	24	44	48	86
2.445	40	72	44	100	2.743	24	28	32	100	3.055	28	44	48	100
2.450	28	64	56	100	2.750	40	64	44	100	3.055	24	44	56	100
2.456	44	86	48	100	2.778	32	64	40	72	3.056	32	64	44	72
2.481	32	72	48	86	2.778	24	48	40	72	3.056	28	56	44	72
2.481	24	72	64	86	2.778	40	56	28	72	3.056	24	48	44	72
2.489	32	72	56	100	2.791	28	56	48	86	3.070	24	40	44	86
2.489	28	72	64	100	2.791	32	64	48	86	3.080	28	40	44	100

TABLE OF LEADS, 3.086″ TO 3.896″

	DRIVEN	DRIVER	DRIVER	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
3.086	24	56	72	100	3.349	48	40	24	86	3.637	48	44	24	72
3.101	40	72	48	86	3.360	56	40	24	100	3.646	40	48	28	64
3.101	32	48	40	86	3.360	48	40	28	100	3.655	40	56	44	86
3.111	28	40	32	72	3.383	32	44	40	86	3.657	64	56	32	100
3.111	40	72	56	100	3.403	28	64	56	72	3.663	72	64	28	86
3.117	24	44	32	56	3.409	24	44	40	64	3.667	40	48	44	100
3.125	28	56	40	64	3.411	32	48	44	86	3.667	44	40	24	72
3.125	24	48	40	64	3.411	44	72	48	86	3.673	24	28	24	56
3.126	48	86	56	100	3.422	44	72	56	100	3.684	44	86	72	100
3.140	24	86	72	64	3.428	24	40	32	56	3.686	86	56	24	100
3.143	40	56	44	100	3.429	40	28	24	100	3.704	32	48	40	72
3.150	28	100	72	64	3.429	40	56	48	100	3.721	24	24	32	86
3.175	32	56	40	72	3.438	24	48	44	64	3.721	64	48	24	86
3.182	28	44	32	64	3.438	28	56	44	64	3.721	64	56	28	86
3.182	24	44	28	48	3.488	40	64	48	86	3.733	48	72	56	100
3.189	32	56	48	86	3.488	40	32	24	86	3.733	56	48	32	100
3.189	24	28	32	86	3.491	64	44	24	100	3.733	64	48	28	100
3.190	24	86	64	56	3.491	48	44	32	100	3.733	28	24	32	100
3.198	40	64	44	86	3.492	32	56	44	72	3.750	24	32	24	48
3.200	28	100	64	56	3.500	40	64	56	100	3.750	24	32	28	56
3.200	24	100	64	48	3.500	28	32	40	100	3.750	28	56	48	64
3.200	24	24	32	100	3.500	28	40	32	64	3.763	86	64	28	100
3.214	24	56	48	64	3.500	24	40	28	48	3.771	44	56	48	100
3.214	24	32	24	56	3.520	32	40	44	100	3.772	24	28	44	100
3.214	24	28	24	64	3.535	28	44	40	72	3.799	56	48	28	86
3.225	24	100	86	64	3.552	56	44	24	86	3.809	24	28	32	72
3.241	28	48	40	72	3.552	48	44	28	86	3.810	64	56	24	72
3.256	24	24	28	86	3.556	40	72	64	100	3.810	32	56	48	72
3.256	24	86	56	48	3.564	56	44	28	100	3.818	24	40	28	44
3.256	32	64	56	86	3.565	28	48	44	72	3.819	40	64	44	72
3.267	28	48	56	100	3.571	24	48	40	56	3.822	86	72	32	100
3.273	24	40	24	44	3.571	32	56	40	64	3.837	24	32	44	86
3.275	44	86	64	100	3.572	48	86	64	100	3.837	44	64	48	85
3.281	24	32	28	64	3.582	44	40	28	86	3.840	64	40	24	100
3.300	44	64	48	100	3.588	72	56	24	86	3.840	32	40	48	100
3.300	44	32	24	100	3.600	72	48	24	100	3.850	44	64	56	100
3.308	32	72	64	86	3.600	72	64	32	100	3.850	28	32	44	100
3.333	32	64	48	72	3.600	72	56	28	100	3.876	24	72	100	86
3.333	28	56	48	72	3.600	48	32	24	100	3.889	32	64	56	72
3.333	28	48	32	56	3.618	56	72	40	86	3.889	56	48	24	72
3.345	28	100	86	72	3.636	24	44	32	48	3.889	24	24	28	72
3.349	40	86	72	100	3.636	28	44	32	56	3.896	24	44	40	56

TABLE OF LEADS, 3.907″ TO 4.778″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
3.907	28	40	48	86	4.200	48	64	56	100	4.480	56	40	32	100
3.907	56	40	24	86	4.200	56	32	24	100	4.480	64	40	28	100
3.911	44	72	64	100	4.200	28	32	48	100	4.500	72	64	40	100
3.920	28	40	56	100	4.200	72	48	28	100	4.500	48	40	24	64
3.927	72	44	24	100	4.242	28	44	32	48	4.500	24	32	24	40
3.929	32	56	44	64	4.242	28	44	48	72	4.522	100	72	28	86
3.929	24	48	44	56						4.537	56	48	28	72
3.977	28	44	40	64	4.242	24	44	56	72	4.545	24	44	40	48
3.979	44	72	56	86	4.253	64	56	32	86	4.546	28	44	40	56
3.987	24	28	40	86	4.264	40	48	44	86	4.546	32	44	40	64
3.987	40	56	48	86	4.267	64	48	32	100	4.548	44	72	64	86
4.000	24	40	32	48	4.267	48	72	64	100	4.558	56	40	28	86
4.000	28	40	32	56	4.278	28	40	44	72	4.567	72	44	24	86
4.000	24	24	40	100	4.286	24	28	24	48	4.572	40	56	64	100
4.000	24	40	48	72	4.286	24	28	32	64	4.572	32	28	40	100
4.011	28	48	44	64	4.286	32	56	48	64	4.582	72	44	28	100
4.019	72	86	48	100	4.300	86	56	28	100	4.583	44	64	48	72
4.040	32	44	40	72	4.300	86	64	32	100	4.583	44	32	24	72
4.059	32	44	48	86	4.300	86	48	24	100	4.584	32	48	44	64
4.060	64	44	24	86	4.320	72	40	24	100	4.584	28	48	44	56
4.070	28	32	40	86	4.341	48	72	56	86	4.651	40	24	24	86
4.070	40	64	56	86	4.341	56	48	32	86	4.655	64	44	32	100
4.073	64	44	28	100	4.342	64	48	28	86	4.667	28	40	32	48
4.073	56	44	32	100	4.342	28	24	32	86	4.667	40	24	28	100
4.074	32	48	44	72	4.361	100	64	24	86	4.667	56	40	24	72
4.091	24	44	48	64	4.363	24	40	32	44	4.667	48	40	28	72
4.091	24	32	24	44	4.364	40	44	48	100	4.667	40	48	56	100
4.093	32	40	44	86	4.365	40	56	44	72	4.675	24	28	24	44
4.114	48	28	24	100	4.375	24	24	28	64	4.675	48	44	24	56
4.114	72	56	32	100	4.375	24	32	28	48	4.687	40	32	24	64
4.125	24	40	44	64	4.375	56	48	24	64	4.688	56	86	72	100
4.135	40	72	64	86	4.386	24	28	44	86	4.691	86	44	24	100
4.144	56	44	28	86	4.386	44	56	48	86	4.714	44	40	24	56
4.167	28	48	40	56	4.400	24	24	44	100	4.736	64	44	28	86
4.167	40	64	48	72	4.444	64	56	28	72	4.736	56	44	32	86
4.167	32	48	40	64	4.444	24	24	32	72	4.762	40	28	24	72
4.167	24	32	40	72	4.444	64	48	24	72	4.762	40	48	32	56
4.167	56	86	64	100	4.465	64	40	24	86	4.762	40	56	48	72
4.186	72	64	32	86	4.466	48	40	32	86	4.773	24	32	28	44
4.186	48	32	24	86	4.477	44	32	28	86	4.773	56	44	24	64
4.186	72	48	24	86	4.477	56	64	44	86	4.773	48	44	28	64
4.186	72	56	28	86	4.479	86	64	24	72	4.778	86	72	40	100

TABLE OF LEADS, 4.784" TO 5.733"

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
4.784	72	56	32	86	5.116	44	24	24	86	5.358	64	86	72	100
4.785	48	28	24	86	5.119	86	56	24	72	5.375	86	64	40	100
4.800	48	24	24	100	5.120	64	40	32	100	5.400	72	32	24	100
4.800	56	28	24	100	5.133	56	48	44	100	5.400	72	64	48	100
4.800	64	32	24	100	5.134	44	24	28	100	5.413	64	44	32	86
4.800	72	48	32	100	5.142	72	56	40	100	5.426	40	24	28	86
4.813	44	40	28	64	5.143	24	28	24	40	5.427	40	48	56	86
4.821	72	56	24	64	5.143	24	40	48	56	5.444	56	40	28	72
4.849	32	44	48	72	5.156	44	32	24	64	5.455	48	44	28	56
4.849	64	44	24	72	5.160	86	40	24	100	5.455	32	44	48	64
4.861	40	32	28	72	5.168	100	72	32	86	5.469	40	32	28	64
4.861	56	64	40	72	5.185	28	24	32	72	5.473	86	44	28	100
4.884	48	64	56	86	5.186	64	48	28	72	5.486	64	28	24	100
4.884	72	48	28	86	5.186	56	48	32	72	5.486	48	28	32	100
4.884	48	32	28	86	5.195	32	44	40	56	5.486	48	56	64	100
4.884	56	32	24	86	5.209	100	64	24	72	5.500	44	40	24	48
4.889	32	40	44	72	5.210	64	40	28	86	5.500	44	40	32	64
4.898	24	28	32	56	5.210	56	40	32	86	5.500	40	32	44	100
4.900	56	32	28	100	5.226	86	64	28	72	5.500	44	40	28	56
4.911	40	56	44	64	5.233	72	64	40	86	5.556	40	24	24	72
4.914	86	56	32	100	5.236	72	44	32	100	5.568	56	44	28	64
4.950	56	44	28	72	5.238	44	28	24	72	5.581	64	32	24	86
4.950	72	64	44	100	5.238	32	48	44	56	5.581	56	28	24	86
4.961	64	48	32	86	5.238	44	56	48	72	5.581	72	48	32	86
4.961	64	72	48	86	5.250	24	32	28	40	5.582	48	24	24	86
4.978	56	72	64	100	5.250	56	40	24	64	5.600	56	24	24	100
4.984	100	56	24	86	5.250	48	40	28	64	5.600	48	24	28	100
5.000	24	24	28	56	5.256	86	72	44	100	5.600	64	32	28	100
5.000	24	24	32	64	5.280	48	40	44	100	5.625	48	32	24	64
5.000	48	32	24	72	5.303	28	44	40	48	5.625	72	48	24	64
5.017	86	48	28	100	5.316	40	28	32	86	5.625	72	56	28	64
5.023	72	40	24	86	5.316	40	56	64	86	5.657	56	44	32	72
5.029	44	28	32	100	5.328	72	44	28	86	5.657	72	56	44	100
5.029	64	56	44	100	5.333	40	24	32	100	5.657	64	44	28	72
5.040	72	40	28	100	5.333	64	40	24	72	5.698	56	32	28	86
5.074	40	44	48	86	5.333	32	40	48	72	5.714	48	28	24	72
5.080	64	56	32	72	5.333	40	48	64	100	5.714	24	28	32	48
5.088	100	64	28	86	5.347	44	64	56	72	5.714	24	24	32	56
5.091	56	44	40	100	5.348	44	32	28	72	5.714	64	48	24	56
5.091	28	40	32	44	5.357	40	28	24	64	5.730	40	48	44	64
5.093	40	48	44	72	5.357	40	32	24	56	5.733	86	48	32	100
5.105	28	48	56	64	5.357	40	56	48	64	5.733	86	72	48	100

TABLE OF LEADS, 5.756″ TO 6.757″

LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW
5.756	72	64	44	86	6.089	72	44	32	86	6.417	44	40	28	48
5.759	86	56	24	64	6.109	56	44	48	100	6.429	24	28	24	32
5.760	72	40	32	100	6.112	24	24	44	72	6.429	48	28	24	64
5.788	64	72	56	86	6.122	40	28	24	56	6.429	48	32	24	56
5.814	100	64	32	86	6.125	56	40	28	64	6.429	72	48	24	56
5.814	100	56	28	86	6.137	72	44	24	64	6.429	72	56	32	64
5.814	100	48	24	86	6.140	48	40	44	86	6.450	86	64	48	100
5.818	64	44	40	100	6.143	86	56	40	100	6.450	86	32	24	100
5.833	28	24	24	48	6.160	56	40	44	100	6.460	100	72	40	86
5.833	32	24	28	64						6.465	64	44	32	72
5.833	56	32	24	72	6.171	72	56	48	100	6.482	56	48	40	72
5.833	48	32	28	72	6.172	72	28	24	100	6.482	40	24	28	72
5.833	56	48	32	64	6.202	40	24	32	86	6.512	56	24	24	86
5.833	56	64	48	72	6.202	64	48	40	86	6.512	64	32	28	86
5.847	64	56	44	86	6.222	64	40	28	72	6.512	48	24	28	86
5.848	44	28	32	86	6.222	56	40	32	72	6.515	86	44	24	72
5.861	72	40	28	86	6.234	32	28	24	44	6.534	56	24	28	100
5.867	44	24	32	100	6.234	64	44	24	56	6.545	48	40	24	44
5.867	64	48	44	100	6.234	48	44	32	56	6.545	72	44	40	100
5.893	44	32	24	56	6.250	24	24	40	64	6.548	44	48	40	56
5.893	44	28	24	64	6.250	40	32	24	48	6.563	56	32	24	64
5.893	48	56	44	64	6.250	40	32	28	56	6.563	72	48	28	64
5.912	86	64	44	100	6.255	86	44	32	100	6.563	48	32	28	64
5.920	56	44	40	86	6.279	72	64	48	86	6.578	72	56	44	86
5.926	64	48	32	72	6.279	72	32	24	86	6.600	48	32	44	100
5.952	100	56	24	72	6.286	44	40	32	56	6.600	72	48	44	100
5.954	64	40	32	86	6.286	44	28	40	100	6.645	100	56	32	86
5.969	44	24	28	86	6.300	72	32	28	100	6.667	64	48	28	56
5.969	56	48	44	86	6.300	72	64	56	100	6.667	32	24	28	56
5.972	86	48	24	72	6.343	100	44	24	86	6.667	32	24	24	48
5.972	86	56	28	72	6.350	40	28	32	72	6.667	48	24	24	72
5.972	86	64	32	72	6.350	64	56	40	72	6.667	56	28	24	72
5.980	72	56	40	86	6.364	56	44	24	48	6.667	64	32	24	72
6.000	48	40	28	56	6.364	56	44	32	64	6.689	86	72	56	100
6.000	48	40	32	64	6.364	24	24	28	44	6.697	100	56	24	64
6.000	48	32	40	100	6.379	64	28	24	86	6.698	72	40	32	86
6.000	72	48	40	100	6.379	48	28	32	86	6.719	86	48	24	64
6.016	44	32	28	64	6.379	64	56	48	86	6.719	86	56	28	64
6.020	86	40	28	100	6.396	44	32	40	86	6.720	56	40	48	100
6.061	40	44	32	48	6.400	64	24	24	100	6.735	44	28	24	56
6.061	48	44	40	72	6.400	48	24	32	100	6.750	72	40	24	64
6.077	100	64	28	72	6.400	56	28	32	100	6.757	86	56	44	100

TABLE OF LEADS, 6.766″ TO 7.883″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
6.766	64	44	40	86	7.159	72	44	28	64	7.525	86	32	28	100
6.784	100	48	28	86	7.163	56	40	44	86	7.525	86	64	56	100
6.806	56	32	28	72	7.167	86	40	24	72	7.543	48	28	44	100
6.818	40	32	24	44	7.167	86	48	40	100	7.576	100	44	24	72
6.818	48	44	40	64	7.176	72	28	24	86	7.597	56	24	28	86
6.822	44	24	32	86	7.176	72	56	48	86	7.601	86	44	28	72
6.822	64	48	44	86	7.200	72	24	24	100	7.611	72	44	40	86
6.825	86	56	32	72	7.268	100	64	40	86	7.619	64	48	32	56
6.857	32	28	24	40	7.272	64	44	28	56	7.619	64	56	48	72
6.857	64	40	24	56	7.273	32	24	24	44	7.620	64	28	24	72
6.857	48	40	32	56	7.273	64	44	24	48	7.620	48	28	32	72
6.857	48	28	40	100	7.292	56	48	40	64	7.636	56	40	24	44
6.875	44	24	24	64	7.292	40	32	28	48	7.636	48	40	28	44
6.875	44	32	24	48	7.292	40	24	28	64	7.639	44	32	40	72
6.875	44	32	28	56	7.310	44	28	40	86	7.644	86	72	64	100
6.880	86	40	32	100	7.314	64	28	32	100	7.657	56	32	28	64
6.944	100	48	24	72	7.326	72	32	28	86	7.674	72	48	44	86
6.944	100	64	32	72	7.326	72	64	56	86	7.675	48	32	44	86
6.945	100	56	28	72	7.330	86	44	24	64	7.679	86	48	24	56
6.968	86	48	28	72	7.333	44	24	40	100	7.679	86	56	32	64
6.977	48	32	40	86	7.333	48	40	44	72	7.680	64	40	48	100
6.977	100	40	24	86	7.334	44	40	32	48	7.700	56	32	44	100
6.977	72	48	40	86	7.347	48	28	24	56	7.714	72	40	24	56
6.982	64	44	48	100	7.371	86	56	48	100	7.752	100	48	32	86
6.984	44	28	32	72	7.372	86	28	24	100	7.752	100	72	48	86
6.984	64	56	44	72	7.400	100	44	28	86	7.778	32	24	28	48
7.000	28	24	24	40	7.408	40	24	32	72	7.778	56	24	24	72
7.000	56	40	24	48	7.408	64	48	40	72	7.778	48	24	28	72
7.000	56	40	32	64	7.424	56	44	28	48	7.778	64	32	28	72
7.000	56	32	40	100	7.442	64	24	24	86	7.792	40	28	24	44
7.013	72	44	24	56	7.442	48	24	32	86	7.792	48	44	40	56
7.040	64	40	44	100	7.442	56	28	32	86	7.813	100	48	24	64
7.071	56	44	40	72	7.465	86	64	40	72	7.813	100	56	28	64
					7.467	64	24	28	100	7.815	56	40	48	86
7.104	56	44	48	86						7.818	86	44	40	100
7.106	100	72	44	86	7.467	56	24	32	100	7.838	86	48	28	64
7.111	64	40	32	72	7.467	64	48	56	100	7.855	72	44	48	100
7.130	44	24	28	72	7.500	48	24	24	64	7.857	44	24	24	56
7.130	56	48	44	72	7.500	56	28	24	64	7.857	44	28	24	48
7.143	40	28	32	64	7.500	48	32	28	56	7.872	44	28	32	64
7.143	40	28	24	48	7.500	72	48	28	56	7.875	72	40	28	64
7.143	40	24	24	56	7.500	72	48	32	64	7.883	86	48	44	100

TABLE OF LEADS, 7.920″ TO 9.302″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
7.920	72	40	44	100	8.333	48	32	40	72	8.772	48	28	44	86
7.936	100	56	32	72	8.333	100	40	24	72	8.800	48	24	44	100
7.954	40	32	28	44	8.334	40	24	28	56	8.800	64	32	44	100
7.955	56	44	40	64	8.361	86	40	28	72	8.800	56	28	44	100
7.963	86	48	32	72	8.372	72	24	24	86	8.838	100	44	28	72
7.974	48	28	40	86	8.377	86	44	24	56	8.839	72	56	44	64
7.994	100	64	44	86	8.400	72	24	28	100	8.889	64	24	24	72
8.000	64	32	40	100	8.400	56	32	48	100	8.889	56	28	32	72
8.000	32	24	24	40	8.400	72	48	56	100	8.889	48	24	32	72
8.000	64	40	24	48	8.437	72	32	24	64	8.909	56	40	28	44
8.000	64	40	28	56	8.457	100	44	32	86	8.929	100	48	24	56
8.000	56	28	40	100	8.484	32	24	28	44	8.929	100	56	32	64
8.000	48	24	40	100	8.485	64	44	28	48	8.930	64	40	48	86
8.021	44	32	28	48	8.485	56	44	32	48	8.953	56	32	44	86
8.021	44	24	28	64	8.485	56	44	48	72	8.959	86	48	28	56
8.021	56	48	44	64	8.506	64	28	32	86	8.959	86	32	24	72
8.035	72	56	40	64	8.523	100	44	24	64	8.959	86	64	48	72
8.063	86	40	24	64	8.527	44	24	40	86	8.959	86	48	28	56
8.081	64	44	40	72	8.532	86	56	40	72	8.960	64	40	56	100
8.102	100	48	28	72	8.534	64	24	32	100	8.980	44	28	32	56
8.119	64	44	48	86	8.552	86	44	28	64	9.000	48	32	24	40
8.140	56	32	40	86	8.556	56	40	44	72	9.000	72	40	24	48
8.140	100	40	28	86	8.572	64	32	24	56	9.000	72	40	28	56
8.145	64	44	56	100	8.572	48	28	32	64	9.000	72	40	32	64
8.148	64	48	44	72	8.572	48	24	24	56	9.000	72	32	40	100
8.149	44	24	32	72	8.572	72	48	32	56	9.044	100	72	56	86
8.163	40	28	32	56	8.594	44	32	40	64	9.074	56	24	28	72
8.167	56	40	28	48	8.600	86	24	24	100	9.091	40	24	24	44
8.182	48	32	24	44	8.640	72	40	48	100	9.115	100	48	28	64
8.182	72	44	24	48	8.681	100	64	40	72	9.134	72	44	48	86
8.182	72	44	28	56	8.682	64	24	28	86	9.137	100	56	44	86
8.182	72	44	32	64	8.682	56	24	32	86	9.143	64	40	32	56
8.186	64	40	44	86	8.682	64	48	56	86	9.143	64	28	40	100
8.212	86	64	44	72	8.687	86	44	32	72	9.164	72	44	56	100
8.229	72	28	32	100	8.721	100	32	24	86	9.167	44	24	24	48
8.229	72	56	64	100	8.721	100	64	48	86	9.167	44	24	28	56
8.250	44	32	24	40	8.727	48	40	32	44	9.167	44	24	32	64
8.250	48	40	44	64	8.730	44	28	40	72	9.167	48	32	44	72
8.306	100	56	40	86	8.750	28	24	24	32	9.210	72	40	44	86
8.312	64	44	32	56	8.750	56	32	24	48	9.214	86	40	24	56
8.333	40	24	24	48	8.750	56	24	24	64	9.260	100	48	32	72
8.333	40	24	32	64	8.750	48	24	28	64	9.302	48	24	40	86

TABLE OF LEADS, 9.303″ TO 10.477″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
9.303	56	28	40	86	9.675	86	64	72	100	10.101	100	44	32	72
9.303	64	32	40	86	9.690	100	48	40	86	10.159	64	28	32	72
9.303	100	40	32	86	9.697	64	48	32	44	10.175	100	32	28	86
9.333	64	40	28	48	9.697	64	44	48	72	10.175	100	64	56	86
9.333	56	40	32	48	9.723	40	24	28	48	10.182	64	40	28	44
9.333	56	24	40	100	9.723	56	32	40	72	10.182	56	40	32	44
9.333	56	40	48	72	9.723	100	40	28	72	10.186	44	24	40	72
9.334	32	24	28	40	9.741	100	44	24	56	10.209	56	24	28	64
9.351	48	28	24	44	9.768	72	48	56	86	10.209	56	32	28	48
9.351	72	44	32	56	9.768	56	32	48	86	10.228	72	44	40	64
9.375	48	32	40	64	9.768	72	24	28	86	10.233	48	24	44	86
9.375	100	40	24	64	9.773	86	44	24	48	10.233	56	28	44	86
9.375	72	48	40	64	9.773	86	44	28	56	10.233	64	32	44	86
9.382	86	44	48	100	9.773	86	44	32	64	10.238	86	28	24	72
9.385	86	56	44	72	9.778	64	40	44	72	10.238	86	48	32	56
9.406	86	40	28	64	9.796	64	28	24	56	10.238	86	56	48	72
9.428	44	28	24	40	9.796	48	28	32	56	10.267	56	24	44	100
9.429	48	40	44	56	9.818	72	40	24	44	10.286	48	28	24	40
9.460	86	40	44	100	9.822	44	32	40	56	10.286	72	40	32	56
9.472	64	44	56	86	9.822	44	28	40	64	10.286	72	28	40	100
9.524	40	28	32	48	9.828	86	28	32	100	10.312	48	32	44	64
9.524	40	24	32	56	9.828	86	56	64	100	10.313	72	48	44	64
9.524	48	28	40	72	9.844	72	32	28	64	10.320	86	40	48	100
9.524	64	48	40	56	9.900	72	32	44	100	10.336	100	72	64	86
9.545	72	44	28	48	9.921	100	56	40	72	10.370	64	24	28	72
9.546	56	32	24	44	9.923	64	24	32	86	10.370	56	24	32	72
9.546	48	32	28	44	9.943	100	44	28	64	10.371	64	48	56	72
9 547	56	44	48	64	9.954	86	48	40	72	10.390	40	28	32	44
9.549	100	64	44	72	9.967	100	56	48	86	10.390	64	44	40	56
9.556	86	40	32	72	9.968	100	28	24	86	10.417	100	32	24	72
9.569	72	28	32	86	10.000	56	28	24	48	10.417	100	48	28	56
9.569	72	56	64	86	10.000	48	24	28	56	10.417	100	48	32	64
9.598	86	56	40	64	10.000	64	32	24	48	10.417	100	64	48	72
9.600	72	24	32	100	10.000	64	32	28	56	10.419	64	40	56	86
9.600	56	28	48	100	10.000	56	28	32	64	10.451	86	32	28	72
9.600	64	32	48	100	10.000	48	24	32	64	10.451	86	64	56	72
9.600	72	48	64	100	10.033	86	24	28	100	10.467	72	32	40	86
9.625	44	32	28	40	10.033	86	48	56	100	10.473	72	44	64	100
9.625	56	40	44	64	10.046	72	40	48	86	10.476	44	24	32	56
9.643	72	32	24	56	10.057	64	28	44	100	10.476	44	28	32	48
9.643	72	28	24	64	10.078	86	32	24	64	10.477	48	28	44	72
9.643	72	56	48	64	10.080	72	40	56	100	10.477	64	48	44	56

TABLE OF LEADS, 10.500″ TO 12.272″

Lead in Inches	Driven: Gear on Worm	Driver: 1st Gear on Stud	Driven: 2nd Gear on Stud	Driver: Gear on Screw	Lead in Inches	Driven: Gear on Worm	Driver: 1st Gear on Stud	Driven: 2nd Gear on Stud	Driver: Gear on Screw	Lead in Inches	Driven: Gear on Worm	Driver: 1st Gear on Stud	Driven: 2nd Gear on Stud	Driver: Gear on Screw
10.500	56	32	24	40	11.111	48	24	40	72	11.667	64	32	28	48
10.500	48	32	28	40	11.111	56	28	40	72	11.667	56	32	48	72
10.500	72	40	28	48	11.111	64	32	40	72	11.667	56	24	32	64
10.500	56	40	48	64	11.111	100	40	32	72	11.688	72	44	40	56
10.558	86	56	44	64	11.137	56	32	28	44	11.695	64	28	44	86
10.571	100	44	40	86	11.160	100	56	40	64	11.719	100	32	24	64
10.606	56	44	40	48	11.163	72	24	32	86	11.721	72	40	56	86
10.606	40	24	28	44	11.163	56	28	48	86	11.728	86	40	24	44
10.631	64	28	40	86	11.163	72	48	64	86	11.733	64	24	44	100
10.655	72	44	56	86	11.163	64	32	48	86	11.757	86	32	28	64
10.659	100	48	44	86	11.169	86	44	32	56	11.785	72	48	44	56
10.667	64	40	48	72	11.198	86	48	40	64	11.786	44	28	24	32
10.667	64	24	40	100	11.200	56	24	48	100	11.786	48	32	44	56
10.667	64	40	32	48	11.200	64	32	56	100	11.786	48	28	44	64
10.694	44	24	28	48	11.225	44	28	40	56	11.825	86	32	44	100
10.694	56	32	44	72	11.250	72	24	24	64	11.852	64	24	32	72
10.713	40	28	24	32	11.250	72	32	24	48	11.905	100	28	24	72
10.714	48	32	40	56	11.250	72	32	28	56	11.905	100	48	32	56
10.714	48	28	40	64	11.313	64	44	56	72	11.905	100	56	48	72
10.714	100	40	24	56	11.314	72	28	44	100	11.938	56	24	44	86
10.714	72	48	40	56	11.363	100	44	24	48	11.944	86	24	24	72
10.750	86	40	24	48	11.363	100	44	28	56	11.960	72	28	40	86
10.750	86	40	28	56	11.363	100	44	32	64	12.000	48	24	24	40
10.750	86	40	32	64	11.401	86	44	28	48	12.000	56	28	24	40
10.750	86	32	40	100	11.429	32	24	24	28	12.000	64	32	24	40
10.800	72	32	48	100	11.429	64	28	24	48	12.000	72	40	32	48
10.853	56	24	40	86	11.429	64	24	24	56	12.000	72	24	40	100
10.859	86	44	40	72	11.429	48	24	32	56	12.031	56	32	44	64
10.909	72	44	32	48	11.454	72	40	28	44	12.040	86	40	56	100
10.909	56	28	24	44	11.459	44	24	40	64	12.121	40	24	32	44
10.909	48	24	24	44	11.459	44	32	40	48	12.121	64	44	40	48
10.909	64	32	24	44	11.467	86	24	32	100	12.153	100	32	28	72
10.913	100	56	44	72	11.467	86	48	64	100	12.153	100	64	56	72
10.937	56	32	40	64	11.512	72	32	44	86	12.178	72	44	64	86
10.937	100	40	28	64	11.518	86	28	24	64	12.216	86	44	40	64
10.945	86	44	56	100	11.518	86	32	24	56	12.222	44	24	32	48
10.949	86	48	44	72	11.518	86	56	48	64	12.222	48	24	44	72
10.972	64	28	48	100	11.520	72	40	64	100	12.222	56	28	44	72
11.000	44	24	24	40	11.574	100	48	40	72	12.222	64	32	44	72
11.021	72	28	24	56	11.629	100	24	24	86	12.245	48	28	40	56
11.057	86	56	72	100	11.638	64	40	32	44	12.250	56	32	28	40
11.111	40	24	32	48	11.667	56	24	24	48	12.272	72	32	24	44

TABLE OF LEADS, 12.272″ TO 14.322″

LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW
12.272	72	44	48	64	12.900	86	32	48	100	13.566	100	48	56	86
12.277	100	56	44	64	12.900	86	48	72	100	13.611	56	24	28	48
12.286	86	28	40	100	12.963	56	24	40	72	13.636	48	32	40	44
12.286	86	40	32	56	12.9S7	100	44	32	56	13.636	100	40	24	44
12.318	86	48	44	64	13.020	100	48	40	64	13.636	72	44	40	48
12.343	72	28	48	100	13.024	56	24	48	86	13.643	64	24	44	86
12.375	72	40	44	64	13.024	64	32	56	86	13.650	86	28	32	72
12.403	64	24	40	86	13.030	86	44	32	48	13.650	86	56	64	72
12.444	64	40	56	72	13.030	86	44	48	72	13.672	100	32	28	64
12.468	64	28	24	44	13.062	64	28	32	56	13.682	86	40	28	44
12.468	48	28	32	44	13.082	100	64	72	86	13.713	64	40	48	56
12.468	64	44	48	56	13.090	72	40	32	44	13.715	64	28	24	40
12.500	40	24	24	32	13.096	44	28	40	48	13.715	48	28	32	40
12.500	48	24	40	64	13.096	44	24	40	56	13.750	44	24	24	32
12.500	56	28	40	64	13.125	72	32	28	48	13.750	48	24	44	64
12.500	100	40	24	48	13.125	72	24	28	64	13.750	56	28	44	64
12.500	100	40	28	56	13.125	56	32	48	64	13.760	86	40	64	100
12.500	100	40	32	64	13.125	72	48	56	64	13.889	100	24	24	72
12.542	86	40	28	48	13.139	86	40	44	72	13.933	86	48	56	72
12.508	86	44	64	100	13.157	72	28	44	86	13.935	86	24	28	72
12.558	72	32	48	86	13.163	86	28	24	56	13.953	72	24	40	86
12.571	64	40	44	56	13.200	72	24	44	100	13.953	100	40	48	86
12.572	44	28	32	40	13.258	100	44	28	48	13.960	86	44	40	56
12.600	72	32	56	100	13.289	100	28	32	86	13.968	64	28	44	72
12.627	100	44	40	72	13.289	100	56	64	86	14.000	56	24	24	40
12.686	100	44	48	86	13.333	64	24	24	48	14.000	48	24	28	40
12.698	64	28	40	72	13.333	64	24	28	56	14.000	64	32	28	40
12.727	64	32	28	44	13.333	56	28	32	48	14.025	72	44	48	56
12.728	56	24	24	44	13.333	56	28	48	72	14.026	72	28	24	44
12.728	48	24	28	44	13.333	64	32	48	72	14.063	72	32	40	64
12.732	100	48	44	72	13.393	100	56	48	64	14.071	86	44	72	100
12.758	64	28	48	86	13.393	100	28	24	64	14.078	86	48	44	56
12.791	100	40	44	86	13.393	100	32	24	56	14.142	72	40	44	56
12.798	86	48	40	56	13.396	72	40	64	86	14.204	100	44	40	64
12.800	64	28	56	100	13.437	86	32	28	56	14.260	56	24	44	72
12.800	64	24	48	100	13.438	86	24	24	64	14.286	40	24	24	28
12.834	56	40	44	48	13:438	86	32	24	48	14.286	48	24	40	56
12.834	44	24	28	40	13.469	48	28	44	56	14.286	64	32	40	56
12.857	72	28	32	64	13.500	72	32	24	40	14.286	100	40	32	56
12.857	72	24	24	56	13.500	72	40	48	64	14.318	72	32	28	44
12.857	72	28	24	48	13.514	86	28	44	100	14.319	72	44	56	64
12.858	48	28	24	32	13.566	100	24	28	86	14.322	100	48	44	64

TABLE OF LEADS, 14.333″ TO 16.914″

LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW
14.333	86	40	32	48	15.238	64	28	48	72	15.989	100	32	44	86
14.333	86	24	40	100	15.239	64	28	32	48	16.000	64	24	24	40
14.333	86	40	48	72	15.239	64	24	32	56	16.000	48	24	32	40
14.352	72	28	48	86	15.272	56	40	48	44	16.000	56	28	32	40
14.400	72	24	48	100	15.278	44	24	40	48	16.042	56	24	44	64
14.400	72	28	56	100	15.279	100	40	44	72	16.042	56	32	44	48
14.400	72	32	64	100	15.306	100	28	24	56	16.043	44	24	28	32
14.536	100	32	40	86	15.349	72	24	44	86	16.071	72	32	40	56
14.545	64	24	24	44	15.357	86	28	24	48	16.071	72	28	40	64
14.545	48	24	32	44	15.357	86	24	24	56	16.125	86	32	24	40
14.545	56	28	32	44	15.357	86	28	32	64	16.125	86	40	48	64
14.583	56	32	40	48	15.429	72	40	48	56	16.204	100	24	28	72
14.583	56	24	40	64	15.429	72	28	24	40	16.204	100	48	56	72
14.583	100	40	28	48	15.469	72	32	44	64	16.233	100	44	40	56
14.584	40	24	28	32	15.480	86	40	72	100	16.280	100	40	56	86
14.651	72	32	56	86	15.504	100	48	64	86	16.288	86	44	40	48
14.659	86	44	48	64	15.504	100	24	32	86	16.296	64	24	44	72
14.659	86	32	24	44	15.556	64	32	56	72	16.327	64	28	40	56
14.667	64	40	44	48	15.556	64	24	28	48	16.333	56	24	28	40
14.668	44	24	32	40	15.556	56	24	32	48	16.364	72	24	24	44
14.694	72	28	32	56	15.556	32	24	28	24	16.370	100	48	44	56
14.743	86	28	48	100	15.556	56	24	48	72	16.423	86	32	44	72
14.780	86	40	44	64	15.584	48	28	40	44	16.456	72	28	64	100
14.800	100	44	56	86	15.625	100	24	24	64	16.500	72	40	44	48
14.815	64	24	40	72	15.625	100	32	24	48	16.500	48	32	44	40
14.849	56	24	28	44	15.625	100	32	28	56	16.612	100	28	40	86
14.880	100	48	40	56	15.636	86	40	32	44	16.623	64	28	32	44
14.884	64	28	56	86	15.677	86	32	28	48	16.667	56	28	40	48
14.884	64	24	48	86	15.677	86	24	28	64	16.667	64	32	40	48
14.931	86	32	40	72	15.677	86	48	56	64	16.667	100	40	32	48
14.933	64	24	56	100	15.714	44	24	24	28	16.667	100	40	48	72
14.950	100	56	72	86	15.714	48	24	44	56	16.722	86	40	56	72
15.000	48	24	24	32	15.714	64	32	44	56	16.744	72	24	48	86
15.000	56	28	24	32	15.750	72	32	28	40	16.744	72	28	56	86
15.000	72	24	24	48	15.750	72	40	56	64	16.744	72	32	64	86
15.000	72	24	28	56	15.767	86	24	44	100	16.752	86	44	48	56
15.000	72	24	32	64	15.873	100	56	64	72	16.753	86	28	24	44
15.000	56	28	48	64	15.874	100	28	32	72	16.797	86	32	40	64
15.050	86	32	56	100	15.909	100	40	28	44	16.800	72	24	56	100
15.150	100	44	32	48	15.909	56	32	40	44	16.875	72	32	48	64
15.151	100	44	48	72	15.925	86	48	64	72	16.892	86	40	44	56
15.202	86	44	56	72	15.926	86	24	32	72	16.914	100	44	64	86

TABLE OF LEADS, 16.969″ TO 20.20″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
16.969	64	44	56	48	17.918	86	32	48	72	19.091	72	24	28	44
16.970	64	24	28	44	17.959	64	28	44	56	19.096	100	32	44	72
16.970	56	24	32	44	18.000	72	24	24	40	19.111	86	40	64	72
17.045	100	32	24	44	18.181	56	28	40	44	19.136	72	28	64	86
17.046	100	44	48	64	18.181	64	32	40	44	19.197	86	32	40	56
17.062	86	28	40	72	18.181	100	40	32	44	19.197	86	28	40	64
17.101	86	44	56	64	18.182	48	24	40	44	19.200	72	24	64	100
17.102	86	32	28	44	18.229	100	32	28	48	19.250	56	32	44	40
17.141	64	32	48	56	18.229	100	24	28	64	19.285	72	32	48	56
17.143	64	28	24	32	18.229	100	48	56	64	19.285	72	28	48	64
17.144	48	24	24	28	18.273	100	28	44	86	19.286	72	28	24	32
17.144	72	28	32	48	18.285	64	28	32	40	19.350	86	32	72	100
17.144	72	24	32	56	18.333	56	28	44	48	19.380	100	24	40	86
17.144	72	48	64	56	18.333	64	32	44	48	19.394	64	24	32	44
17.188	100	40	44	64	18.367	72	28	40	56	19.444	40	24	28	24
17.200	86	32	64	100	18.428	86	28	24	40	19.444	56	24	40	48
17.200	86	28	56	100	18.428	86	40	48	56	19.444	100	40	56	72
17.200	86	24	48	100	18.476	86	32	44	64	19 480	100	28	24	44
17.275	86	56	72	64	18.519	100	24	32	72	19.480	100	44	48	56
17.361	100	32	40	72	18.519	100	48	64	72	19.531	100	32	40	64
17.364	64	24	56	86	18.605	100	40	64	86	19.535	72	24	56	86
17.373	86	44	64	72	18.663	100	64	86	72	19.545	86	24	24	44
17.442	100	32	48	86	18.667	64	24	28	40	19.590	64	28	48	56
17.442	100	48	72	86	18.667	56	24	32	40	19.635	72	40	48	44
17.454	64	40	48	44	18.667	64	40	56	48	19.642	100	40	44	56
17.500	56	24	24	32	18.700	72	44	64	56	19.643	44	28	40	32
17.500	48	24	28	32	18.700	72	28	32	44	19.656	86	28	64	100
17.500	72	24	28	48	18.750	100	32	24	40	19.687	72	32	56	64
17.500	56	24	48	64	18.750	72	24	40	64	19.710	86	40	44	48
17.550	86	28	32	56	18.750	72	32	40	48	19.840	100	28	40	72
17.677	100	44	56	72	18.750	100	40	48	64	19.886	100	44	56	64
17.679	72	32	44	56	18.770	86	28	44	72	19.887	100	32	28	44
17.679	72	28	44	64	18.812	86	32	28	40	19.908	86	24	40	72
17.778	64	24	32	48	18.812	86	40	56	64	19.934	100	28	48	86
17.778	64	24	48	72	18.858	48	28	44	40	20.00	72	24	32	48
17.778	64	28	56	72	18.939	100	44	40	48	20.00	64	24	24	32
17.858	100	24	24	56	19.029	100	44	72	86	20.00	56	24	24	28
17.858	100	28	32	64	19.048	40	24	32	28	20.07	86	24	56	100
17.858	100	28	24	48	19.048	64	24	40	56	20.09	100	56	72	64
17.917	86	24	32	64	19.048	64	28	40	48	20.16	86	48	72	64
17.917	86	24	28	56	19.090	56	32	48	44	20.16	86	32	48	64
17.918	86	24	24	48	19.090	72	44	56	48	20.20	100	44	64	72

TABLE OF LEADS, 20.20″ TO 24.55″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
					21.43	100	28	24	40	23.04	86	32	48	56
20.20	72	28	44	56	21.48	100	32	44	64	23.04	86	28	48	64
20.35	100	32	56	86	21.50	86	24	24	40	23.04	86	28	24	32
20.36	64	40	56	44	21.82	72	44	64	48	23.14	100	24	40	72
20.41	100	28	32	56	21.82	100	28	44	72	23.26	100	32	64	86
20.42	56	24	28	32	21.82	64	32	48	44	23.26	100	28	56	86
20.45	72	32	40	44	21.82	56	28	48	44	23.26	100	24	48	86
20.48	86	48	64	56	21.82	72	24	32	44	23.33	64	32	56	48
20.48	86	28	48	72	21.88	100	40	56	64	23.33	48	24	28	24
20.48	86	28	32	48	21.88	100	32	28	40	23.33	64	24	28	32
20.48	86	24	32	56	21.90	86	24	44	72	23.38	72	28	40	44
20.57	72	40	64	56	21.94	86	28	40	56	23.44	100	48	72	64
20.57	72	28	32	40	21.99	86	44	72	64	23.44	100	32	48	64
20.63	72	32	44	48	22.00	64	32	44	40	23.45	86	40	48	44
20.63	72	24	44	64	22.00	48	24	44	40	23.52	86	32	56	64
20.74	64	24	56	72	22.00	56	28	44	40	23.57	72	28	44	48
20.78	64	28	40	44	22.04	72	28	48	56	23.57	72	24	44	56
20.83	100	32	48	72	22.11	86	28	72	100	23.57	48	28	44	32
20.83	100	24	32	64	22.22	100	40	64	72					
20.83	100	24	28	56	22.22	40	24	32	24	23.81	100	48	64	56
20.83	100	24	24	48	22.22	64	24	40	48	23.81	100	28	48	72
20.90	86	32	56	72	22.32	72	24	64	86	23.81	100	28	32	48
20.90	86	24	28	48	22.32	100	32	40	56	23.81	100	24	32	56
20.93	100	40	72	86	22.32	100	28	40	64	23.89	86	32	64	72
20.95	64	28	44	48	22.34	86	44	64	56	23.89	86	28	56	72
20.95	64	24	44	56	22.34	86	28	32	44	23.89	86	24	48	72
20.95	44	24	32	28	22.40	86	32	40	48	23.89	86	24	32	48
21.00	56	32	48	40	22.40	86	24	40	64	24.00	64	40	72	48
21.00	72	40	56	48	22.50	72	24	48	64	24.00	72	24	32	40
21.00	72	24	28	40	22.50	72	24	24	32	24.00	56	28	48	40
21.12	86	32	44	56	22.50	72	28	56	64	24.00	64	32	48	40
21.12	86	28	44	64	22.73	100	24	24	44	24.00	100	56	86	64
21.21	56	24	40	44	22.80	86	48	56	44	24.13	86	28	44	56
21.32	100	24	44	86	22.80	86	24	28	44	24.19	86	40	72	64
21.33	100	56	86	72	22.86	64	24	24	28	24.24	64	24	40	44
21.33	64	24	32	40	22.86	48	24	32	28	24.31	100	32	56	72
21.39	44	24	28	24	22.86	64	24	48	56	24.31	100	24	28	48
21.39	56	24	44	48	22.91	72	44	56	40	24.43	86	32	40	44
21.43	100	40	48	56	22.92	100	40	44	48	24.44	44	24	32	24
21.43	72	28	40	48	22.92	44	24	40	32	24.44	64	24	44	48
21.43	72	24	40	56	22.93	86	24	64	100	24.54	72	32	48	44
21.43	48	28	40	32	23.04	86	56	72	48	24.55	100	32	44	56

TABLE OF LEADS, 24.55″ TO 31.11″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
24.55	100	28	44	64	26.52	100	24	28	44	28.57	100	56	64	40
24.57	86	40	64	56	26.58	100	28	64	86	28.57	48	28	40	24
24.57	86	28	32	40	26.67	64	28	56	48	28.57	64	32	40	28
24.64	86	24	44	64	26.67	56	24	32	28	28.57	100	28	32	40
24.64	86	32	44	48	26.67	48	24	32	24	28.64	72	44	56	32
24.75	72	32	44	40	26.79	100	48	72	56	28.65	100	32	44	48
24.88	100	72	86	48	26.79	100	32	48	56	28.65	100	24	44	64
24.93	64	28	48	44	26.79	100	28	48	64	28.67	86	40	64	48
25.00	72	24	40	48	26.79	100	28	24	32	28.67	86	24	32	40
25.00	48	24	40	32	26.88	86	28	56	64	29.09	64	24	48	44
25.00	56	28	40	32	26.88	86	24	48	64	29.09	64	28	56	44
25.00	100	24	24	40	26.88	86	24	24	32	29.17	100	40	56	48
25.08	86	24	28	40	27.00	72	32	48	40	29.17	56	24	40	32
25.09	86	40	56	48	27.13	100	24	56	86	29.17	100	24	28	40
25.13	86	44	72	56	27.15	100	44	86	72	29.22	100	56	72	44
25.14	64	28	44	40	27.22	56	24	28	24	29.32	86	48	72	44
25.45	64	44	56	32	27.27	100	40	48	44	29.32	86	32	48	44
25.45	56	24	48	44	27.27	72	24	40	44	29.34	64	24	44	40
25.46	100	24	44	72	27.30	86	28	64	72	29.39	72	28	64	56
25.51	100	28	40	56	27.34	100	32	56	64	29.56	86	32	44	40
25.57	100	64	72	44	27.36	86	40	56	44	29.76	100	28	40	48
25.60	86	28	40	48	27.43	64	28	48	40	29.76	100	24	40	56
25.60	86	24	40	56	27.50	56	32	44	28	29.86	100	40	86	72
25.67	56	24	44	40	27.50	48	24	44	32	29.86	86	24	40	48
25.71	72	24	48	56	27.50	72	24	44	48	29.90	100	28	72	86
25.71	72	56	64	32	27.64	86	40	72	56	30.00	56	28	48	32
25.72	72	24	24	28	27.78	100	32	64	72	30.00	72	32	64	48
25.80	86	24	72	100	27.78	100	28	56	72	30.00	72	28	56	48
25.97	100	44	64	56	27.78	100	24	48	72	30.23	86	32	72	64
25.97	100	28	32	44	27.78	100	24	32	48	30.30	100	48	64	44
26.04	100	32	40	48	27.87	86	24	56	72	30.30	100	24	32	44
26.04	100	24	40	64	27.92	86	28	40	44	30.48	64	24	32	28
26.06	86	44	64	48	28.00	100	64	86	48	30.54	100	44	86	64
26.06	86	24	32	44	28.00	64	32	56	40	30.56	44	24	40	24
26.16	100	32	72	86	28.00	56	24	48	40	30.61	100	28	48	56
26.18	72	40	64	44	28.05	72	28	48	44	30.71	86	24	48	56
26.19	44	24	40	28	28.06	100	28	44	56	30.71	86	32	64	56
26.25	72	32	56	48	28.13	100	40	72	64	30.72	86	24	24	28
26.25	72	24	56	64	28.15	86	28	44	48	30.86	72	28	48	40
26.25	72	24	28	32	28.15	85	24	44	56	31.01	100	24	64	86
26.33	86	28	48	56	28.29	72	28	44	40	31.11	64	24	56	48
26.52	100	44	56	48	28.41	100	32	40	44	31.11	56	24	32	24

TABLE OF LEADS, 31.11″ TO 41.99″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
31.11	64	24	28	24	34.09	100	44	48	32	37.50	72	24	40	32
31.25	100	28	56	64	34.20	86	44	56	32	37.63	86	32	56	40
31.25	100	24	48	64	34.29	72	48	64	28	37.88	100	24	40	44
31.25	100	24	24	32	34.29	72	24	64	56	38.10	64	24	40	28
31.27	86	40	64	44	34.29	64	32	48	28	38.18	72	24	56	44
31.35	86	32	56	48	34.29	72	24	32	28	38.20	100	24	44	48
31.35	86	24	56	64	34.38	100	32	44	40	38.39	100	40	86	56
31.36	86	24	28	32	34.55	86	32	72	56	38.39	86	28	40	32
31.43	64	28	44	32	34.55	86	28	72	64	38.57	72	28	48	32
31.43	48	24	44	28	34.72	100	24	40	48	38.89	56	24	40	24
31.50	72	32	56	40	34.88	100	24	72	86	38.96	100	28	48	44
31.75	100	72	64	28	34.90	100	56	86	44	39.09	86	32	64	44
31.82	100	44	56	40	35.00	72	24	56	48	39.09	86	28	56	44
31.85	86	24	64	72	35.00	56	24	48	32	39.09	86	24	48	44
31.99	100	56	86	48	35.00	72	24	28	24	39.29	100	28	44	40
32.00	64	28	56	40	35.10	86	28	64	56	39.42	86	24	44	40
32.00	64	24	48	40	35.16	100	32	72	64					
32.09	56	24	44	32	35.18	86	44	72	40	39.49	86	28	72	56
32.14	100	56	72	40	35.36	72	32	44	28	39.77	100	32	56	44
32.14	72	28	40	32	35.56	64	24	32	24	40.00	72	24	64	48
32.25	86	48	72	40	35.71	100	32	64	56	40.00	64	28	56	32
32.25	86	40	48	32	35.71	100	24	48	56	40.00	64	24	48	32
32.41	100	24	56	72	35.72	100	24	24	28	40.00	56	24	48	28
32.47	100	28	40	44	35.83	86	32	64	48	40.00	72	24	32	24
32.58	86	24	40	44	35.83	86	28	56	48	40.18	100	32	72	56
32.73	72	32	64	44	36.00	72	32	64	40	40.18	100	28	72	64
32.73	72	28	56	44	36.00	72	28	56	40	40.31	86	32	72	48
32.73	72	24	48	44	36.00	72	24	48	40	40.31	86	24	72	64
32.74	100	28	44	48	36.36	100	44	64	40	40.72	100	44	86	48
32.74	100	24	44	56	36.46	100	48	56	32	40.82	100	28	64	56
32.85	86	24	44	48	36.46	100	24	56	64	40.91	100	40	72	44
33.00	72	24	44	40	36.46	100	24	28	32	40.95	86	28	64	48
33.33	100	24	32	40	36.67	48	24	44	24	40.95	86	24	64	56
33.33	100	48	64	40	36.67	64	24	44	32	40.96	86	24	32	28
33.33	64	24	40	32	36.67	56	24	44	28	41.14	72	28	64	40
33.33	56	24	40	28	36.86	86	28	48	40	41.25	72	24	44	32
33.33	48	24	40	24	37.04	100	24	64	72	41.67	100	32	64	48
33.51	86	28	48	44	37.33	100	32	86	72	41.67	100	28	56	48
33.59	100	64	86	40	37.33	64	24	56	40	41.81	86	24	56	48
33.79	86	28	44	40	37.40	72	28	64	44	41.81	86	24	28	24
33.94	64	24	56	44	37.50	100	48	72	40	41.91	64	24	44	28
34.09	100	48	72	44	37.50	100	32	48	40	41.99	100	32	86	64

TABLE OF LEADS, 42.00″ TO 74.65″

	DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER		DRIVEN	DRIVER	DRIVEN	DRIVER
LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW	LEAD IN INCHES	GEAR ON WORM	1ST GEAR ON STUD	2ND GEAR ON STUD	GEAR ON SCREW
42 00	72	24	56	40	48.00	72	24	64	40	56.31	86	24	44	28
					48.38	86	32	72	40	57.14	100	28	64	40
42.23	86	28	44	32	48.61	100	24	56	48	57.30	100	24	44	32
42.66	100	28	86	72	48.61	100	24	28	24	57.33	86	24	64	40
42.78	56	24	44	24	48.86	100	40	86	44	58.33	100	24	56	40
42.86	100	28	48	40	48.89	64	24	44	24	58.44	100	28	72	44
42.86	72	24	40	28	49.11	100	28	44	32	58.64	86	24	72	44
43.00	86	32	64	40	49.14	86	28	64	40	59.53	100	24	40	28
43.00	86	28	56	40	49.27	86	24	44	32	59.72	86	24	40	24
43.00	86	24	48	40	49.77	100	24	86	72	60.00	72	24	64	32
43.64	72	24	64	44	50.00	100	28	56	40	60.00	72	24	56	28
43.75	100	32	56	40	50.00	100	24	48	40	60.00	72	24	48	24
43.98	86	32	72	44	50.00	72	24	40	24	60.61	100	24	64	44
44.44	64	24	40	24	50.00	100	32	64	40	61.08	100	32	86	44
44.64	100	28	40	32	50.17	86	24	56	40	61.43	86	28	64	32
44.68	86	28	64	44	50.26	86	28	72	44	61.43	86	24	48	28
44.79	100	40	86	48	51.14	100	32	72	44	62.22	64	24	56	24
44.79	86	24	40	32	51.19	86	24	40	28	62.50	100	24	72	48
45.00	72	28	56	32	51.43	72	28	64	32	62.50	100	28	56	32
45.00	72	24	48	32	51.43	72	24	48	28	62.50	100	24	48	32
45.45	100	32	64	44	51.95	100	28	64	44	62.71	86	24	56	32
45.45	100	24	48	44	52.08	100	24	40	32	63.99	100	28	86	48
45.46	100	28	56	44	52.12	86	24	64	44	63.99	100	24	86	56
45 61	86	24	56	44	52.50	72	24	56	32	64.29	100	28	72	40
45.72	64	24	48	28	53.03	100	24	56	44	64.50	86	24	72	40
45.84	100	24	44	40	53.33	64	24	56	28	65.48	100	24	44	28
45.92	100	28	72	56	53.33	64	24	48	24	65.70	86	24	44	24
46.07	86	28	72	48	53.57	100	28	72	48	66.67	100	24	64	40
46.07	86	24	72	56	53.57	100	24	72	56	67.19	100	32	86	40
46.07	86	28	48	32						68.18	100	24	72	44
46.67	64	24	56	32	53.57	100	28	48	32	68.57	72	24	64	28
46.67	56	24	48	24	53.75	86	24	72	48	69.11	86	28	72	32
46.88	100	32	72	48	53.75	86	24	48	32	69.44	100	24	40	24
46.88	100	24	72	64	53.75	86	28	56	32	69.80	100	28	86	44
47.15	72	24	44	28	54.85	100	28	86	56	70.00	72	24	56	24
47.62	100	28	64	48	55.00	72	24	44	24	71.43	100	28	64	32
47.62	100	24	64	56	55.28	86	28	72	40	71.43	100	24	48	28
47.62	100	24	32	28	55.56	100	24	32	24	71.67	86	24	64	32
47.78	86	24	64	48	55.56	100	24	64	48	71.67	86	24	56	28
47.78	86	24	32	24	55.99	100	24	86	64	71.67	86	24	48	24
47.99	100	32	86	56	55.99	100	32	86	48	72.92	100	24	56	32
47.99	100	28	86	64	56.25	100	32	72	40	74.65	100	24	86	48

TABLE OF LEADS, 75.00″ TO 149.31″

LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW	LEAD IN INCHES	DRIVEN GEAR ON WORM	DRIVER 1ST GEAR ON STUD	DRIVEN 2ND GEAR ON STUD	DRIVER GEAR ON SCREW
75.00	100	24	72	40										
76.39	100	24	44	24										
76.79	100	28	86	40										
80.00	72	24	64	24										
80.36	100	28	72	32										
80.63	86	24	72	32										
81.44	100	24	86	44										
81.90	86	24	64	28										
83.33	100	24	64	32										
83.33	100	24	56	28										
83.33	100	24	48	24										
83.61	86	24	56	24										
89.59	100	24	86	40										
92.14	86	24	72	28										
93.75	100	24	72	32										
95.24	100	24	64	28										
95.56	86	24	64	24										
95.98	100	28	86	32										
97.22	100	24	56	24										
107.14	100	24	72	28										
107.50	86	24	72	24										
111.11	100	24	64	24										
111.98	100	24	86	32										
125.00	100	24	72	24										
127.98	100	24	86	28										
149.31	100	24	86	24										

TABLES OF LEADS FOR CAM LOBES

Obtained with Spiral Head and a Vertical Spindle Milling Attachment Set at an Angle

The method of using the Spiral Head and a Vertical Spindle Milling Attachment for cutting the lobes of cams is described in Chapter IX, and the following tables have been worked out to enable the machine to be set up without the necessity of figuring the leads and settings.

In compiling these tables, we have employed the same combinations of change gears as those in the "Table of Approximate Angles for Cutting Spirals," all of which will reach without interfering. The practical leads obtainable with each set of change gears have been grouped together so that when a machine is set for any lead, and it is desired to change to another lead, the operator can quickly determine whether the required lead is available without changing the gears already on. As this is often the case in this work, the saving in time that is effected is readily appreciated.

A selection of leads from 0 to 20″ is listed, and it should be understood that these are the leads or amount of rise in a complete circle, not the amount of rise of a lobe in a fractional part of the circumference. From the amount of rise of the lobe it will be necessary before using these tables to calculate the lead or rise if the lobe were continued the full circumference. This is easily found as explained on page 177.

In using these tables to set up a machine to mill any required lead, the column under the heading "Approximate Lead" is first followed down until the range of leads is found which embraces the required one. Then follow the horizontal line across until the nearest dimension to the exact lead required is found. At the top of the column containing this dimension will be found the required combination of change gears, and in the next two columns at the right, and in line with the dimension selected, will be found the angles at which to set the spiral head and vertical milling attachment.

Example: Required, the change gears and angles at which to set the spiral head and vertical milling attachment for a lead of .1476″.

Following down the first column we find .145-50, which embraces the required lead. Following this line across horizontally we find .1474″, which is sufficiently near to .1476″ for all practical purposes. At the top of the column containing .1474″ is the proper combination of change gears, 24, 86, 32, and 100, and in the two columns at the right and in line with .1474″ are the necessary angles; $9\frac{1}{2}°$ for spiral head, and $80\frac{1}{2}°$ for vertical milling attachment.

When the machine is already set for a given lead and it is desired to know whether another required lead can be obtained without changing the gears, proceed as follows:

Example: Machine is set with a combination of gears, 24, 72, 32, and 86, and a lead of .1080″ is required.

Follow down the column of exact leads that are given under the combination of change gears for which the machine is set until .1081″ is found. This is sufficiently near to .1080″ for all practical purposes. Hence it is possible to obtain this lead without changing the gears, by setting the spiral head at 5° and the vertical milling attachment at 85°.

In milling cams in this way an angle of greater than 80° with the spiral head, which is the greatest angle listed in these tables, should be avoided to prevent going beyond the range of the spiral head.

A vertical spindle milling attachment with offset spindle, like that shown on page 77, is preferable for this work, as it will reach nearer to the spiral head spindle when milling small cams with the heads set nearly vertical.

We also manufacture an extension by the use of which the spiral head can be moved farther in on the table to bring the spiral head and vertical spindle attachment spindles nearer together. This extension is furnished on special order.

The standard end mill is of sufficient length for practically all leads on ordinary screw machine cams, for long leads usually extend over only a partial turn of the cam.

The mill should be of the same diameter as the roll to be used with the cam, and, in laying out the cam, work from the centre of the roll.

LEADS FROM .000 TO .150

Approximate Lead	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 24, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.000-05	.0029	1/4	89 3/4	.0034	1/4	89 3/4	.0039	1/4	89 3/4	.0047	1/4	89 3/4
.005-10	.0088	3/4	89 1/4	.0068	1/2	89 1/2	.0078	1/2	89 1/2	.0095	1/2	89 1/2
.010-15	.0117	1	89	.0102	3/4	89 1/4	.0117	3/4	89 1/4	.0142	3/4	89 1/4
.015-20	.0175	1 1/2	88 1/2	.0170	1 1/4	88 3/4	.0195	1 1/4	88 3/4	.0189	1	89
.020-25	.0234	2	88	.0205	1 1/2	88 1/2	.0234	1 1/2	88 1/2	.0237	1 1/4	88 3/4
.025-30	.0263	2 1/4	87 3/4	.0273	2	88	.0273	1 3/4	88 1/4	.0284	1 1/2	88 1/2
.030-35	.0321	2 3/4	87 1/4	.0341	2 1/2	87 1/2	.0312	2	88	.0331	1 3/4	88 1/4
.035-40	.0351	3	87	.0375	2 3/4	87 1/4	.0390	2 1/2	87 1/2	.0379	2	88
.040-45	.0409	3 1/2	86 1/2	.0443	3 1/4	86 3/4	.0428	2 3/4	87 1/4	.0426	2 1/4	87 3/4
.045-50	.0497	4 1/4	85 3/4	.0477	3 1/2	86 1/2	.0467	3	87	.0473	2 1/2	87 1/2
.050-55	.0526	4 1/2	85 1/2	.0511	3 3/4	86 1/4	.0545	3 1/2	86 1/2	.0521	2 3/4	87 1/4
.055-60	.0584	5	85	.0579	4 1/4	85 3/4	.0584	3 3/4	86 1/4	.0568	3	87
.060-65	.0642	5 1/2	84 1/2	.0613	4 1/2	85 1/2	.0623	4	86	.0615	3 1/4	86 3/4
.065-70	.0671	5 3/4	84 1/4	.0681	5	85	.0662	4 1/4	85 3/4	.0662	3 1/2	86 1/2
.070-75	.0700	6	84	.0749	5 1/2	84 1/2	.0739	4 3/4	85 1/4	.0710	3 3/4	86 1/4
.075-80	.0758	6 1/2	83 1/2	.0782	5 3/4	84 1/4	.0778	5	85	.0757	4	86
.080-85	.0846	7 1/4	82 3/4	.0816	6	84	.0817	5 1/4	84 3/4	.0804	4 1/4	85 3/4
.085-90	.0875	7 1/2	82 1/2	.0884	6 1/2	83 1/2	.0895	5 3/4	84 1/4	.0899	4 3/4	85 1/4
.090-95	.0932	8	82	.0918	6 3/4	83 1/4	.0933	6	84	.0946	5	85
.095-00	.0961	8 1/4	81 3/4	.0952	7	83	.0972	6 1/4	83 3/4	.0993	5 1/4	84 3/4
.100-05	.1048	9	81	.1020	7 1/2	82 1/2	.1011	6 1/2	83 1/2	.1040	5 1/2	84 1/2
.105-10	.1077	9 1/4	80 3/4	.1053	7 3/4	82 1/4	.1088	7	83	.1087	5 3/4	84 1/4
.110-15	.1106	9 1/2	80 1/2	.1121	8 1/4	81 3/4	.1127	7 1/4	82 3/4	.1134	6	84
.115-20	.1163	10	80	.1155	8 1/2	81 1/2	.1166	7 1/2	82 1/2	.1181	6 1/4	83 3/4
.120-25	.1221	10 1/2	79 1/2	.1222	9	81	.1204	7 3/4	82 1/4	.1228	6 1/2	83 1/2
.125-30	.1250	10 3/4	79 1/4	.1289	9 1/2	80 1/2	.1281	8 1/4	81 3/4	.1275	6 3/4	83 1/4
.130-35	.1336	11 1/2	78 1/2	.1323	9 3/4	80 1/4	.1320	8 1/2	81 1/2	.1322	7	83
.135-40	.1393	12	78	.1356	10	80	.1397	9	81	.1369	7 1/4	82 3/4
.140-45	.1421	12 1/4	77 3/4	.1424	10 1/2	79 1/2	.1435	9 1/4	80 3/4	.1416	7 1/2	82 1/2
.145-50	.1450	12 1/2	77 1/2	.1491	11	79	.1474	9 1/2	80 1/2	.1463	7 3/4	82 1/4

Approximate Lead	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.000-05												
.005-10	.0054	1/4	89 3/4	.0058	1/4	89 3/4	.0061	1/4	89 3/4	.0065	1/4	89 3/4
.010-15	.0108	1/2	89 1/2	.0116	1/2	89 1/2	.0122	1/2	89 1/2	.0131	1/2	89 1/2
.015-20	.0162	3/4	89 1/4	.0174	3/4	89 1/4	.0183	3/4	89 1/4	.0196	3/4	89 1/4
.020-25	.0216	1	89	.0233	1	89	.0244	1	89			
.025-30	.0271	1 1/4	88 3/4	.0291	1 1/4	88 3/4				.0262	1	89
.030-35	.0327	1 1/2	88 1/2	.0349	1 1/2	88 1/2	.0305	1 1/4	88 3/4	.0327	1 1/4	88 3/4
.035-40	.0379	1 3/4	88 1/4				.0367	1 1/2	88 1/2	.0393	1 1/2	88 1/2
.040-45	.0433	2	88	.0407	1 3/4	88 1/4	.0428	1 3/4	88 1/4			
.045-50	.0487	2 1/4	87 3/4	.0465	2	88	.0489	2	88	.0458	1 3/4	88 1/4
.050-55	.0541	2 1/2	87 1/2	.0524	2 1/4	87 3/4				.0524	2	88
.055-60	.0595	2 3/4	87 1/4	.0582	2 1/2	87 1/2	.0550	2 1/4	87 3/4	.0589	2 1/4	87 3/4
.060-65	.0649	3	87	.0640	2 3/4	87 1/4	.0611	2 1/2	87 1/2			
.065-70				.0698	3	87	.0672	2 3/4	87 1/4	.0654	2 1/2	87 1/2
.070-75	.0703	3 1/4	86 3/4				.0733	3	87	.0720	2 3/4	87 1/4
.075-80	.0757	3 1/2	86 1/2	.0756	3 1/4	86 3/4	.0794	3 1/4	86 3/4	.0785	3	87
.080-85	.0811	3 3/4	86 1/4	.0814	3 1/2	86 1/2						
.085-90	.0865	4	86	.0872	3 3/4	86 1/4	.0855	3 1/2	86 1/2	.0850	3 1/4	86 3/4
.090-95	.0919	4 1/4	85 3/4	.0930	4	86	.0916	3 3/4	86 1/4	.0916	3 1/2	86 1/2
.095-00	.0973	4 1/2	85 1/2	.0988	4 1/4	85 3/4	.0978	4	86	.0981	3 3/4	86 1/4
.100-05	.1027	4 3/4	85 1/4	.1046	4 1/2	85 1/2	.1038	4 1/4	85 3/4	.1046	4	86
.105-10	.1081	5	85				.1098	4 1/2	85 1/2	.		
.110-15	.1135	5 1/4	84 3/4	.1104	4 3/4	85 1/4				.1112	4 1/4	85 3/4
.115-20	.1188	5 1/2	84 1/2	.1162	5	85	.1159	4 3/4	85 1/4	.1177	4 1/2	85 1/2
.120-25	.1242	5 3/4	84 1/4	.1220	5 1/4	84 3/4	.1220	5	85	.1242	4 3/4	85 1/4
.125-30	.1296	6	84	.1278	5 1/2	84 1/2	.1281	5 1/4	84 3/4			
.130-35				.1336	5 3/4	84 1/4	.1342	5 1/2	84 1/2	.1307	5	85
.135-40	.1350	6 1/4	83 3/4	.1393	6	84				.1372	5 1/4	84 3/4
.140-45	.1404	6 1/2	83 1/2				.1403	5 3/4	84 1/4	.1438	5 1/2	84 1/2
.145-50	.1458	6 3/4	83 1/4	.1452	6 1/4	83 3/4	.1463	6	84			

LEADS FROM .150 TO .300

Approximate Lead	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 24, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.150-55	.1535	13¼	76¾	.1524	11¼	78¾	.1512	9¾	80¼	.1510	8	82
.155-60	.1564	13½	76½	.1591	11¾	78¼	.1551	10	80	.1557	8¼	81¾
.160-65	.1621	14	76	.1624	12	78	.1627	10½	79½	.1604	8½	81½
.165-70	.1677	14½	75½	.1691	12½	77½	.1666	10¾	79¼	.1650	8¾	81¼
.170-75	.1734	15	75	.1724	12¾	77¼	.1704	11	79	.1744	9¼	80¾
.175-80	.1790	15½	74½	.1757	13	77	.1780	11½	78½	.1791	9½	80½
.180-85	.1847	16	74	.1824	13½	76½	.1818	11¾	78¼	.1837	9¾	80¼
.185-90	.1875	16¼	73¾	.1890	14	76	.1857	12	78	.1884	10	80
.190-95	.1903	16½	73½	.1923	14¼	75¾	.1933	12½	77½	.1931	10¼	79¾
.195-00	.1959	17	73	.1989	14¾	75¼	.1971	12¾	77¼	.1977	10½	79½
.200-05	.2014	17½	72½	.2022	15	75	.2009	13	77	.2024	10¾	79¼
.205-10	.2070	18	72	.2055	15¼	74¾	.2085	13½	76½	.2070	11	79
.210-15	.2126	18½	71½	.2121	15¾	74¼	.2122	13¾	76¼	.2117	11¼	78¾
.215-20	.2181	19	71	.2154	16	74	.2160	14	76	.2163	11½	78½
.220-25	.2236	19½	70½	.2219	16½	73½	.2231	14½	75½	.2210	11¾	78¼
.225-30	.2291	20	70	.2284	17	73	.2274	14¾	75¼	.2256	12	78
.230-35	.2346	20½	69½	.2349	17½	72½	.2311	15	75	.2302	12¼	77¾
.235-40	.2373	20¾	69¼	.2382	17¾	72¼	.2386	15½	74½	.2395	12¾	77¼
.240-45	.2401	21	69	.2415	18	72	.2424	15¾	74¼	.2441	13	77
.245-50	.2482	21¾	68¼	.2479	18½	71½	.2462	16	74	.2487	13¼	76¾
.250-55	.2510	22	68	.2544	19	71	.2536	16½	73½	.2533	13½	76½
.255-60	.2564	22½	67½	.2576	19¼	70¾	.2574	16¾	73¼	.2579	13¾	76¼
.260-65	.2618	23	67	.2640	19¾	70¼	.2648	17¼	72¾	.2625	14	76
.265-70	.2698	23¾	66¼	.2672	20	70	.2685	17½	72½	.2671	14¼	75¾
.270-75	.2725	24	66	.2704	20¼	69¾	.2722	17¾	72¼	.2717	14½	75½
.275-80	.2778	24½	65½	.2768	20¾	69¼	.2760	18	72	.2762	14¾	75¼
.280-85	.2831	25	65	.2800	21	69	.2833	18½	71½	.2808	15	75
.285-90	.2884	25½	64½	.2864	21½	68½	.2871	18¾	71¼	.2854	15¼	74¾
.290-95	.2937	26	64	.2927	22	68	.2907	19	71	.2900	15½	74½
.295-00	.2963	26¼	63¾	.2990	22½	67½	.2981	19½	70½	.2991	16	74

Approximate Lead	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.150-55	.1511	7	83	.1509	6½	83½	.1524	6¼	83¾	.1503	5¾	84¼
.155-60	.1565	7¼	82¾	.1568	6¾	83¼	.1585	6½	83½	.1568	6	84
.160-65	.1619	7½	82½	.1625	7	83	.1645	6¾	83¼	.1633	6¼	83¾
.165-70	.1672	7¾	82¼	.1683	7¼	82¾				.1698	6½	83½
.170-75	.1726	8	82	.1741	7½	82½	.1706	7	83			
.175-80	.1779	8¼	81¾	.1798	7¾	82¼	.1767	7¼	82¾	.1763	6¾	83¼
.180-85	.1833	8½	81½				.1828	7½	82½	.1828	7	83
.185-90	.1887	8¾	81¼	.1856	8	82	.1888	7¾	82¼	.1893	7¼	82¾
.190-95	.1942	9	81	.1914	8¼	81¾	.1948	8	82			
.195-00	.1993	9¼	81¾	.1971	8½	81½				.1958	7½	82½
.200-05	.2047	9½	81½	.2029	8¾	81¼	.2009	8¼	81¾	.2023	7¾	82¼
.205-10				.2086	9	81	.2068	8½	81½	.2088	8	82
.210-15	.2100	9¾	81¼	.2143	9¼	80¾	.2130	8¾	81¼			
.215-20	.2153	10	80				.2190	9	81	.2152	8¼	81¾
.220-25	.2207	10¼	79¾	.2201	9½	80½				.2217	8½	81½
.225-30	.2260	10½	79½	.2258	9¾	80¼	.2250	9¼	80¾	.2282	8¾	81¼
.230-35	.2313	10¾	79¼	.2316	10	80	.2311	9½	80½	.2347	9	81
.235-40	.2366	11	79	.2373	10¼	79¾	.2371	9¾	79¼			
.240-45	.2420	11¼	78¾	.2430	10½	79½	.2431	10	80	.2411	9¼	80¾
.245-50	.2473	11½	78½	.2487	10¾	79¼	.2491	10¼	79¾	.2476	9½	80½
.250-55	.2526	11¾	78¼	.2545	11	79				.2540	9¾	80¼
.255-60	.2579	12	78				.2552	10½	79½			
.260-65	.2632	12¼	77¾	.2601	11¼	78¾	.2612	10¾	79¼	.2605	10	80
.265-70	.2685	12½	77½	.2659	11½	78½	.2672	11	79	.2669	10¼	79¾
.270-75	.2738	12¾	77¼	.2716	11¾	78¼	.2732	11¼	78¾	.2734	10½	79½
.275-80	.2790	13	77	.2773	12	78	.2791	11½	78½	.2798	10¾	79¼
.280-85	.2843	13¼	76¾	.2829	12¼	77¾						
.285-90	.2896	13½	76½	.2886	12½	77½	.2851	11¾	78¼	.2862	11	79
.290-95	.2948	13¾	76¼	.2943	12¾	77¼	.2911	12	78	.2926	11¼	78¾
.295-00				.2999	13	77	.2971	12¼	77¾	.2991	11½	78½

LEADS FROM .300 TO .450

Approximate Lead	Gear on Worm 24 / 1st on Stud 86 / 2nd on Stud 24 / Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24 / 1st on Stud 86 / 2nd on Stud 28 / Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24 / 1st on Stud 86 / 2nd on Stud 32 / Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24 / 1st on Stud 72 / 2nd on Stud 28 / Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.300-05	.3042	27	63	.3021	22¾	67¼	.3018	19¾	70¼	.3036	16¼	73¾
.305-10	.3068	27¼	62¾	.3053	23	67	.3054	20	70	.3082	16½	73½
.310-15	.3145	28	62	.3115	23½	66½	.3127	20½	69½	.3127	16¾	73¼
.315-20	.3197	28½	61½	.3178	24	66	.3164	20¾	69¼	.3173	17	73
.320-25	.3248	29	61	.3240	24½	65½	.3200	21	69	.3218	17¼	72¾
.325-30	.3299	29½	60½	.3271	24¾	65¼	.3273	21½	68½	.3263	17½	72½
.330-35	.3324	29¾	60¼	.3302	25	65	.3345	22	68	.3308	17¾	72¼
.335-40	.3350	30	60	.3364	25½	64½				.3353	18	72
.340-45	.3400	30½	59½	.3425	26	64	.3417	22½	67½	.3443	18½	71½
.345-50	.3451	31	59	.3487	26½	63½	.3489	23	67	.3488	18¾	71¼
.350-55	.3500	31½	58½	.3547	27	63	.3525	23¼	66¾	.3532	19	71
.355-60	.3550	32	58	.3578	27¼	62¾	.3561	23½	66½	.3577	19¼	70¾
.360-65	.3600	32½	57½	.3608	27½	62½	.3632	24	66	.3622	19½	70½
.365-70	.3650	33	57	.3668	28	62	.3667	24¼	65¾	.3666	19¾	70¼
.370-75	.3746	34	56	.3728	28½	61½	.3703	24½	65½	.3711	20	70
.375-80	.3794	34½	55½	.3788	29	61	.3774	25	65	.3755	20¼	69¾
.380-85	.3842	35	55	.3848	29½	60½	.3809	25¼	64¾	.3800	20½	69½
.385-90	.3866	35¼	54¾	.3877	29¾	60¼	.3880	25¾	64¼	.3888	21	69
.390-95	.3937	36	54	.3907	30	60	.3915	26	64	.3932	21¼	68¾
.395-00	.3985	36½	53½	.3967	30½	59½	.3985	26½	63½	.3977	21½	68½
.400-05	.4032	37	53	.4024	31	59	.4020	26¾	63¼	.4021	21¾	68¼
.405-10	.4078	37½	52½	.4083	31½	58½	.4054	27	63	.4065	22	68
.410-15	.4101	37¾	52¼	.4140	32	58	.4123	27½	62½	.4108	22¼	67¾
.415-20	.4170	38½	51½	.4198	32½	57½	.4192	28	62	.4152	22½	67½
.420-25	.4216	39	51	.4227	32¾	57¼	.4227	28¼	61¾	.4239	23	67
.425-30	.4261	39½	50½	.4256	33	57	.4261	28½	61½	.4283	23¼	66¾
.430-35	.4306	40	50	.4313	33½	56½	.4329	29	61	.4326	23½	66½
.435-40	.4351	40½	49½	.4369	34	56	.4397	29½	60½	.4370	23¾	66¼
.440-45	.4439	41½	48½	.4426	34½	55½	.4431	29¾	60¼	.4413	24	66
.445-50	.4482	42	48	.4482	35	55	.4465	30	60	.4456	24¼	65¾

Approximate Lead	Gear on Worm 24 / 1st on Stud 72 / 2nd on Stud 32 / Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24 / 1st on Stud 72 / 2nd on Stud 40 / Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24 / 1st on Stud 48 / 2nd on Stud 28 / Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24 / 1st on Stud 64 / 2nd on Stud 40 / Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.300-05	.3000	14	76				.3030	12½	77½			
.305-10	.3053	14¼	75¾	.3056	13¼	76¾	.3090	12¾	77¼	.3055	11¾	78¼
.310-15	.3106	14½	75½	.3113	13½	76½				.3119	12	78
.315-20	.3158	14¾	75¼	.3169	13¾	76¼	.3150	13	77	.3183	12¼	77¾
.320-25	.3210	15	75	.3226	14	76	.3209	13¼	76¾	.3247	12½	77½
.325-30	.3263	15¼	74¾	.3283	14¼	75¾	.3269	13½	76½			
.330-35	.3315	15½	74½	.3339	14½	75½	.3328	13¾	76¼	.3311	12¾	77¼
.335-40	.3367	15¾	74¼	.3395	14¾	75¼	.3387	14	76	.3375	13	77
.340-45	.3419	16	74				.3446	14¼	75¾	.3438	13¼	76¾
.345-50	.3471	16¼	73¾	.3451	15	75						
.350-55	.3523	16½	73½	.3508	15¼	74¾	.3506	14½	75½	.3502	13½	76½
.355-60	.3575	16¾	73¼	.3563	15½	74½	.3565	14¾	75¼	.3565	13¾	76¼
.360-65	.3627	17	73	.3620	15¾	74¼	.3624	15	75	.3629	14	76
.365-70	.3678	17¼	72¾	.3675	16	74	.3683	15¼	74¾	.3692	14¼	75¾
.370-75	.3730	17½	72½	.3731	16¼	73¾	.3742	15½	74½			
.375-80	.3781	17¾	72¼	.3787	16½	73½				.3756	14½	75½
.380-85	.3833	18	72	.3843	16¾	73¼	.3801	15¾	74¼	.3819	14¾	75¼
.385-90	.3884	18¼	71¾	.3898	17	73	.3859	16	74	.3882	15	75
.390-95	.3936	18½	71½				.3918	16¼	73¾	.3946	15¼	74¾
.395-00	.3987	18¾	71¼	.3954	17¼	72¾	.3977	16½	73½			
.400-05	.4038	19	71	.4011	17½	72½	.4035	16¾	73¼	.4009	15½	74½
.405-10	.4090	19¼	70¾	.4066	17¾	72¼	.4094	17	73	.4072	15¾	74¼
.410-15	.4140	19½	70½	.4121	18	72				.4135	16	74
.415-20	.4191	19¾	70¼	.4176	18¼	71¾	.4152	17¼	72¾	.4198	16¼	73¾
.420-25	.4242	20	70	.4231	18½	71½	.4210	17½	72½			
.425-30	.4293	20¼	69¾	.4287	18¾	71¼	.4268	17¾	72¼	.4260	16½	73½
.430-35	.4344	20½	69½	.4341	19	71	.4327	18	72	.4323	16¾	73¼
.435-40	.4394	20¾	69¼	.4396	19¼	70¾	.4384	18¼	71¾	.4385	17	73
.440-45	.4445	21	69				.4442	18½	71½	.4488	17¼	72¾
.445-50	.4495	21¼	68¾	.4451	19½	70½						

LEADS FROM .450 TO .600

Approximate Lead	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	24 / 86 / 28 / 100	Degrees		24 / 86 / 32 / 100	Degrees		24 / 72 / 28 / 86	Degrees		24 / 72 / 32 / 86	Degrees		24 / 72 / 40 / 100	Degrees		24 / 48 / 28 / 100	Degrees		24 / 64 / 40 / 100	Degrees		28 / 56 / 32 / 100	Degrees	
.450-55	.4537	35½	54½	.4534	30½	59½	.4542	24¾	65¼	.4546	21½	68½	.4506	19¾	70¼	.4500	18¾	71¼	.4511	17½	72½	.4544	16½	73½
.455-60	.4593	36	54	.4566	30¾	59¼	.4585	25	65	.4596	21¾	68¼	.4561	20	70	.4558	19	71	.4573	17¾	72¼			
.460-65	.4648	36½	53½	.4632	31¼	58¾	.4628	25¼	64¾	.4646	22	68	.4615	20¼	69¾	.4616	19¼	70¾	.4635	18	72	.4611	16¾	73¼
.465-70	.4675	36¾	53¼	.4666	31½	58½	.4671	25½	64½	.4696	22¼	67¾	.4670	20½	69½	.4674	19½	70½	.4698	18¼	71¾	.4678	17	73
.470-75	.4702	37	53	.4732	32	58	.4714	25¾	64¼	.4746	22½	67½	.4724	20¾	69¼	.4731	19¾	70¼				.4745	17¼	72¾
.475-80	.4756	37½	52½	.4798	32½	57½	.4756	26	64	.4796	22¾	67¼	.4778	21	69	.4788	20	70	.4759	18½	71½			
.480-85	.4810	38	52	.4831	32¾	57¼	.4842	26½	63½	.4846	23	67	.4833	21¼	68¾	.4846	20¼	69¾	.4822	18¾	71¼	.4811	17½	72½
.485-90	.4890	38¾	51¼	.4864	33	57	.4884	26¾	63¼	.4896	23¼	66¾	.4887	21½	68½				.4883	19	71	.4878	17¾	72¼
.490-95	.4917	39	51	.4929	33½	56½	.4926	27	63	.4946	23½	66½	.4941	21¾	68¼	.4903	20½	69½	.4945	19¼	70¾	.4944	18	72
.495-00	.4970	39½	50½	.4994	34	56	.4968	27¼	62¾	.4995	23¾	66¼	.4995	22	68	.4960	20¾	69¼						
.500-05	.5022	40	50	.5026	34¼	55¾	.5010	27½	62½	.5045	24	66	.5049	22¼	67¾	.5018	21	69	.5007	19½	70½	.5010	18¼	71¾
.505-10	.5075	40½	49½	.5058	34½	55½	.5052	27¾	62¼	.5094	24¼	65¾				.5075	21¼	68¾	.5069	19¾	70¼	.5076	18½	71½
.510-15	.5110	40¾	49¼	.5122	35	55	.5136	28¼	61¾	.5143	24½	65½	.5103	22½	67½	.5131	21½	68½	.5130	20	70	.5143	18¾	71¼
.515-20	.5178	41½	48½	.5186	35½	54½	.5177	28½	61½	.5193	24¾	65¼	.5157	22¾	67¼	.5188	21¾	68¼	.5192	20¼	69¾			
.520-25	.5228	42	48	.5249	36	54	.5218	28¾	61¼	.5241	25	65	.5210	23	67	.5245	22	68				.5209	19	71
.525-30	.5279	42½	47½	.5280	36¼	53¾	.5260	29	61	.5290	25¼	64¾	.5264	23¼	66¾				.5253	20½	69½	.5275	19¼	70¾
.530-35	.5329	43	47	.5312	36½	53½	.5343	29½	60½	.5339	25½	64½	.5317	23½	66½	.5301	22¼	67¾	.5314	20¾	69¼	.5341	19½	70½
.535-40	.5378	43½	46½	.5374	37	53	.5384	29¾	60¼	.5389	25¾	64¼	.5371	23¾	66¼	.5358	22½	67½	.5375	21	69			
.540-45	.5428	44	46	.5405	37¼	52¾	.5425	30	60	.5437	26	64	.5424	24	66	.5414	22¾	67¼	.5436	21¼	68¾	.5407	19¾	70¼
.545-50	.5452	44¼	45¾	.5497	38	52	.5466	30¼	59¾	.5486	26¼	63¾	.5477	24¼	65¾	.5471	23	67	.5497	21½	68½	.5472	20	70
.550-55	.5549	45¼	44¾	.5528	38¼	51¾	.5509	30½	59½	.5534	26½	63½	.5530	24½	65½	.5527	23¼	66¾				.5538	20¼	69¾
.555-60	.5573	45½	44½	.5559	38½	51½	.5588	31	59	.5582	26¾	63¼	.5582	24¾	65¼	.5583	23½	66½	.5558	21¾	68¼			
.560-65	.5644	46¼	43¾	.5619	39	51	.5628	31¼	58¾	.5631	27	63	.5635	25	65	.5639	23¾	66¼	.5619	22	68	.5603	20½	69½
.565-70	.5667	46½	43½	.5650	39¼	50¾	.5669	31½	58½	.5679	27¼	62¾	.5688	25¼	64¾	.5695	24	66	.5680	22¼	67¾	.5668	20¾	69¼
.570-75	.5716	47	43	.5710	39¾	50¼	.5710	31¾	58¼	.5727	27½	62½	.5741	25½	64½				.5740	22½	67½	.5734	21	69
.575-80	.5761	47½	42½	.5770	40¼	49¾	.5750	32	58	.5775	27¾	62¼	.5793	25¾	64¼	.5751	24¼	65¾				.5799	21¼	68¾
.580-85	.5807	48	42	.5800	40½	49½	.5830	32½	57½	.5823	28	62	.5846	26	64	.5806	24½	65½	.5800	22¾	67¼			
.585-90	.5852	48½	41½	.5888	41¼	48¾	.5869	32¾	57¼	.5871	28¼	61¾	.5898	26¼	63¾	.5862	24¾	65¼	.5861	23	67	.5864	21½	68½
.590-95	.5941	49½	40½	.5917	41½	48½	.5909	33	57	.5919	28½	61½	.5949	26½	63½	.5917	25	65	.5921	23¼	66¾	.5928	21¾	68¼
.595-00	.5986	50	40	.5975	42	48	.5988	33½	56½	.5966	28¾	61¼				.5972	25¼	64¾	.5981	23½	66½	.5994	22	68

LEADS FROM .600 TO .750

Approximate Lead	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.600-05	.6033	42½	47½	.6028	33¾	56¼	.6013	29	61	.6002	26¾	63¼
.605-10	.6090	43	47	.6067	34	56	.6060	29¼	60¾	.6054	27	63
.610-15	.6124	43¼	46¾	.6146	34½	55½	.6108	29½	60½	.6106	27¼	62¾
.615-20	.6175	43¾	46¼	.6184	34¾	55¼	.6155	29¾	60¼	.6158	27½	62½
.620-25	.6231	44¼	45¾	.6223	35	55	.6202	30	60	.6209	27¾	62¼
.625-30	.6286	44¾	45¼	.6262	35¼	54¾	.6295	30½	59½	.6260	28	62
.630-35	.6314	45	45	.6300	35½	54½	.6342	30¾	59¼	.6312	28¼	61¾
.635-40	.6369	45½	44½	.6377	36	54	.6388	31	59	.6363	28½	61½
.640-45	.6423	46	44				.6434	31¼	58¾	.6414	28¾	61¼
.645-50	.6477	46½	43½	.6491	36¾	53¼	.6481	31½	58½	.6464	29	61
.650-55	.6504	46¾	43¼	.6530	37	53	.6526	31¾	58¼	.6516	29¼	60¾
.655-60	.6584	47½	42½	.6567	37¼	52¾	.6572	32	58	.6566	29½	60½
.660-65	.6637	48	42	.6605	37½	52½	.6618	32¼	57¾	.6617	29¾	60¼
.665-70	.6688	48½	41½	.6680	38	52	.6664	32½	57½	.6667	30	60
.670-75	.6739	49	41	.6717	38¼	51¾	.6710	32¾	57¼	.6718	30¼	59¾
.675-80	.6790	49½	40½	.6754	38½	51½	.6755	33	57	.6767	30½	59½
.680-85	.6840	50	40	.6828	39	51	.6845	33½	56½	.6818	30¾	59¼
.685-90	.6890	50½	39½	.6865	39¼	50¾	.6890	33¾	56¼	.6868	31	59
.690-95	.6940	51	39	.6901	39½	50½	.6935	34	56	.6918	31¼	58¾
.695-00	.6988	51½	38½	.6974	40	50	.6980	34¼	55¾	.6967	31½	58½
.700-05	.7036	52	38	.7046	40½	49½	.7025	34½	55½	.7017	31¾	58¼
.705-10	.7085	52½	37½	.7082	40¾	49¼	.7070	34¾	55¼	.7066	32	58
.710-15	.7132	53	37	.7118	41	49	.7114	35	55	.7116	32¼	57¾
.715-20	.7178	53½	36½	.7189	41½	48½	.7158	35¼	54¾	.7165	32½	57½
.720-25	.7224	54	36	.7225	41¾	48¼	.7247	35¾	54¼	.7214	32¾	57¼
.725-30	.7270	54½	35½	.7260	42	48	.7291	36	54	.7263	33	57
.730-35	.7315	55	35	.7330	42½	47½	.7334	36¼	53¾	.7312	33¼	56¾
.735-40	.7360	55½	34½	.7397	43	47	.7378	36½	53½	.7360	33½	56½
.740-45	.7404	56	34	.7441	43¼	46¾	.7421	36¾	53¼	.7409	33¾	56¼
.745-50	.7490	57	33	.7467	43½	46½	.7464	37	53	.7456	34	56

Approximate Lead	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.600-05	.6028	25½	64½	.6041	23¾	66¼				.6042	20¾	69¼
.605-10	.6083	25¾	64¼									
.610-15	.6138	26	64	.6101	24	66	.6123	22½	67½	.6112	21	69
.615-20	.6192	26¼	63¾	.6160	24¼	65¾	.6187	22¾	67¼	.6182	21¼	68¾
.620-25	.6247	26½	63½	.6220	24½	65½						
.625-30				.6279	24¾	65¼	.6251	23	67	.6251	21½	68½
.630-35	.6302	26¾	63¼	.6339	25	65	.6316	23¼	66¾	.6320	21¾	68¼
.635-40	.6356	27	63	.6398	25¼	64¾	.6380	23½	66½	.6389	22	68
.640-45	.6410	27¼	62¾				.6444	23¾	66¼			
.645-50	.6465	27½	62½	.6458	25½	64½				.6457	22¼	67¾
.650-55	.6519	27¾	62¼	.6516	25¾	64¼	.6508	24	66	.6526	22½	67½
.655-60	.6573	28	62	.6576	26	64	.6571	24¼	65¾	.6595	22¾	67¼
.660-65	.6627	28¼	61¾	.6634	26¼	63¾	.6634	24½	65½			
.665-70	.6680	28½	61½	.6693	26½	63½	.6698	24¾	65¼	.6664	23	67
.670-75	.6734	28¾	61¼							.6732	23¼	66¾
.675-80	.6788	29	61	.6751	26¾	63¼	.6762	25	65			
.680-85	.6841	29¼	60¾	.6810	27	63	.6825	25¼	64¾	.6801	23½	66½
.685-90	.6894	29½	60½	.6868	27¼	62¾	.6888	25½	64½	.6868	23¾	66¼
.690-95	.6948	29¾	60¼	.6926	27½	62½				.6937	24	66
.695-00				.6984	27¾	62¼	.6951	25¾	64¼			
.700-05	.7000	30	60	.7042	28	62	.7014	26	64	.7004	24¼	65¾
.705-10	.7053	30¼	59¾				.7076	26¼	63¾	.7072	24½	65½
.710-15	.7106	30½	59½	.7100	28¼	61¾	.7140	26½	63½	.7140	24¾	65¼
.715-20	.7159	30¾	59¼	.7157	28½	61½						
.720-25	.7211	31	59	.7214	28¾	61¼	.7202	26¾	63¼	.7208	25	65
.725-30	.7264	31¼	58¾	.7272	29	61	.7264	27	63	.7275	25¼	64¾
.730-35	.7315	31½	58½	.7329	29¼	60¾	.7326	27¼	62¾	.7342	25½	64½
.735-40	.7367	31¾	58¼	.7386	29½	60½	.7387	27½	62½			
.740-45	.7419	32	58	.7443	29¾	60¼	.7449	27¾	62¼	.7409	25¾	64¼
.745-50	.7471	32¼	57¾							.7476	26	64

Leads from .750 to .900

Approximate Lead	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.750-55	.7537	44	46	.7508	37¼	52¾	.7505	34¼	55¾	.7522	32½	57½
.755-60	.7570	44¼	45¾	.7550	37½	52½	.7553	34½	55½	.7573	32¾	57¼
.760-65	.7605	44½	45½	.7636	38	52	.7648	35	55	.7626	33	57
.765-70	.7672	45	45	.7679	38¼	51¾	.7696	35¼	54¾	.7677	33¼	56¾
.770-75	.7738	45½	44½	.7721	38½	51½	.7744	35½	54½	.7728	33½	56½
.775-80	.7772	45¾	44¼	.7763	38¾	51¼	.7790	35¾	54¼	.7778	33¾	56¼
.780-85	.7805	46	44	.7805	39	51	.7838	36	54	.7829	34	56
.785-90	.7869	46½	43½	.7889	39½	50½	.7884	36¼	53¾	.7880	34¼	55¾
.790-95	.7935	47	43	.7930	39¾	50¼	.7932	36½	53½	.7930	34½	55½
.795-00	.7999	47½	42½	.7973	40	50	.7978	36¾	53¼	.7980	34¾	55¼
.800-05	.8030	47¾	42¼	.8014	40¼	49¾	.8025	37	53	.8030	35	55
.805-10	.8064	48	42	.8055	40½	49½	.8072	37¼	52¾	.8080	35¼	54¾
.810-15	.8126	48½	41½	.8137	41	49	.8117	37½	52½	.8131	35½	54½
.815-20	.8188	49	41	.8178	41¼	48¾	.8164	37¾	52¼	.8180	35¾	54¼
.820-25	.8219	49¼	40¾	.8128	41½	48½	.8210	38	52	.8230	36	54
.825-30	.8250	49½	40½	.8299	42	48	.8255	38¼	51¾	.8278	36¼	53¾
.830-35	.8311	50	40	.8339	42¼	47¾	.8301	38½	51½	.8328	36½	53½
.835-40	.8371	50½	39½	.8379	42½	47½	.8391	39	51	.8378	36¾	53¼
.840-45	.8431	51	39	.8419	42¾	47¼	.8437	39¼	50¾	.8426	37	53
.845-50	.8491	51½	38½	.8459	43	47	.8482	39½	50½	.8474	37¼	52¾
.850-55	.8520	51¾	38¼	.8538	43½	46½	.8527	39¾	50¼	.8523	37½	52½
.855-60	.8550	52	38	.8577	43¾	46¼	.8572	40	50	.8572	37¾	52¼
.860-65	.8608	52½	37½	.8616	44	46	.8616	40¼	49¾	.8620	38	52
.865-70	.8665	53	37	.8693	44½	45½	.8660	40½	49½	.8668	38¼	51¾
.870-75	.8722	53½	36½	.8732	44¾	45¼	.8784	41	49	.8716	38½	51½
.875-80	.8778	54	36	.8770	45	45	.8792	41¼	48¾	.8763	38¾	51¼
.880-85	.8832	54½	35½	.8846	45½	44½	.8835	41½	48½	.8810	39	51
.885-90	.8887	55	35	.8884	45¾	44¼	.8880	41¾	48¼	.8858	39¼	50¾
.890-95	.8942	55½	34½	.8922	46	44	.8923	42	48	.8906	39½	50½
.895-00	.8995	56	34	.8996	46½	43½	.8966	42¼	47¾	.8953	39¾	50¼

Approximate Lead	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.750-55	.7500	30	60	.7511	28	62	.7543	26¼	63¾	.7535	24¾	65¼
.755-60	.7556	30¼	59¾	.7573	28¼	61¾						
.760-65	.7613	30½	59½	.7634	28½	61½	.7610	26½	63½	.7607	25	65
.765-70	.7670	30¾	59¼	.7695	28¾	61¼	.7677	26¾	63¼	.7678	25¼	64¾
.770-75	.7725	31	59				.7743	27	63	.7749	25½	64½
.775-80	.7781	31¼	58¾	.7756	29	61						
.780-85	.7837	31½	58½	.7817	29¼	60¾	.7808	27¼	62¾	.7820	25¾	64¼
.785-90	.7892	31¾	58¼	.7878	29½	60½	.7875	27½	62½	.7890	26	64
.790-95	.7948	32	58	.7939	29¾	60¼	.7941	27¾	62¼			
.795-00										.7961	26¼	63¾
.800-05	.8004	32¼	57¾	.8000	30	60	.8007	28	62	.8032	26½	63½
.805-10	.8060	32½	57½	.8060	30¼	59¾	.8073	28¼	61¾			
.810-15	.8114	32¾	57¼	.8120	30½	59½	.8138	28½	61½	.8102	26¾	63¼
.815-20	.8170	33	57	.8180	30¾	59¼				.8172	27	63
.820-25	.8224	33¼	56¾	.8240	31	59	.8203	28¾	61¼	.8241	27¼	62¾
.825-30	.8279	33½	56½				.8268	29	61			
.830-35	.8334	33¾	56¼	.8300	31¼	58¾	.8333	29¼	60¾	.8311	27½	62½
.835-40	.8388	34	56	.8359	31½	58½	.8398	29½	60½	.8380	27¾	62¼
.840-45	.8442	34¼	55¾	.8419	31¾	58¼						
.845-50	.8496	34½	55½	.8478	32	58	.8463	29¾	60¼	.8450	28	62
.850-55				.8538	32¼	57¾	.8527	30	60	.8520	28¼	61¾
.855-60	.8550	34¾	55¼	.8596	32½	57½	.8592	30¼	59¾	.8589	28½	61½
.860-65	.8604	35	55									
.865-70	.8657	35¼	54¾	.8655	32¾	57¼	.8656	30½	59½	.8657	28¾	61¼
.870-75	.8710	35½	54½	.8714	33	57	.8720	30¾	59¼	.8726	29	61
.875-80	.8763	35¾	54¼	.8772	33¼	56¾	.8784	31	59	.8794	29¼	60¾
.880-85	.8816	36	54	.8830	33½	56½	.8847	31¼	58¾			
.885-90	.8869	36¼	53¾	.8888	33¾	56¼				.8863	29½	60½
.890-95	.8922	36½	53½	.8947	34	56	.8911	31½	58½	.8931	29¾	60¼
.895-00	.8974	36¾	53¼				.8975	31¾	58¼			

LEADS FROM .900 TO 1.050

Approximate Lead	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
.900-05	.9047	56½	33½	.9034	46¾	43¼	.9009	42½	46½	.9000	40	50	.9027	37	53	.9004	34¼	55¾	.9037	32	58	.9000	30	60
.905-10	.9074	56¾	33¼	.9071	47	43	.9094	43	47	.9093	40½	49½	.9079	37¼	52¾	.9062	34½	55½				.9068	30¼	59¾
.910-15	.9100	57	33	.9145	47½	42½	.9146	43¼	46¾	.9139	40¾	49¼	.9131	37½	52½	.9120	34¾	55¼	.9101	32¼	57¾	.9136	30½	59½
.915-20	.9151	57½	32½	.9181	47¾	42¼	.9178	43½	46½	.9186	41	49	.9183	37¾	52¼	.9177	35	55	.9164	32½	57½			
.920-25	.9200	58	32	.9217	48	42	.9221	43¾	46¼	.9231	41¼	48¾	.9234	38	52	.9234	35¼	54¾	.9226	32¾	57¼	.9204	30¾	59¼
.925-30	.9250	58½	31½	.9290	48½	41½	.9263	44	46	.9277	41½	48½	.9286	38¼	51¾	.9291	35½	54½	.9288	33	57	.9270	31	59
.930-35	.9300	59	31	.9325	48¾	41¼	.9346	44½	45½	.9323	41¾	48¼	.9337	38½	51½	.9347	35¾	54¼				.9337	31¼	58¾
.935-40	.9395	60	30	.9360	49	41	.9388	44¾	45¼	.9368	42	48	.9388	38¾	51¼				.9351	33¼	56¾			
.940-45	.9443	60½	29½	.9431	49½	40½	.9429	45	45	.9414	42¼	47¾	.9439	39	51	.9404	36	54	.9413	33½	56½	.9404	31½	58½
.945-50	.9489	61	29	.9466	49¾	40¼	.9471	45¼	44¾	.9458	42½	47½	.9490	39¼	50¾	.9460	36¼	53¾	.9475	33¾	56¼	.9471	31¾	58¼
.950-55	.9535	61½	28½	.9501	50	40	.9511	45½	44½	.9548	43	47	.9541	39½	50½	.9516	36½	53½	.9537	34	56	.9538	32	58
.955-60	.9580	62	28	.9570	50½	39½	.9591	46	44	.9593	43¼	46¾	.9592	39¾	50¼	.9572	36¾	53¼	.9598	34¼	55¾			
.960-65	.9624	62½	27½	.9640	51	39	.9633	46¼	43¾	.9638	43½	46½	.9642	40	50	.9629	37	53				.9605	32¼	57¾
.965-70	.9667	63	27	.9673	51¼	38¾	.9672	46½	43½	.9682	43¾	46¼	.9691	40¼	49¾	.9685	37¼	52¾	.9661	34½	55½	.9672	32½	57½
.970-75	.9712	63½	26½	.9707	51½	38½	.9712	46¾	43¼	.9726	44	46	.9741	40½	49½	.9740	37½	52½	.9722	34¾	55¼	.9737	32¾	57¼
.975-80	.9754	64	26	.9774	52	38	.9752	47	43	.9770	44¼	45¾	.9791	40¾	49¼	.9795	37¾	52¼	.9783	35	55			
.980-85	.9836	65	25	.9840	52½	37½	.9831	47½	42½	.9813	44½	45½	.9840	41	49				.9843	35¼	54¾	.9803	33	57
.985-90	.9875	65½	24½	.9863	52¾	37¼	.9870	47¾	42¼	.9856	44¾	45¼	.9890	41¼	48¾	.9850	38	52				.9869	33¼	56¾
.990-95	.9914	66	24	.9906	53	37	.9911	48	42	.9900	45	45	.9938	41½	48½	.9905	38¼	51¾	.9904	35½	54½	.9934	33½	56½
.995-00	.9952	66½	23½	.9970	53½	36½	.9987	48½	41½	.9986	45½	44½	.9988	41¾	48¼	.9959	38½	51½	.9964	35¾	54¼			
1.000-05	1.0027	67½	22½	1.0035	54	36	1.0026	48¾	41¼	1.0028	45¾	44¼	1.0037	42	48	1.0014	38¾	51¼	1.0024	36	54	1.0000	33¾	56¼
1.005-10	1.0062	68	22	1.0098	54½	35½	1.0064	49	41	1.0071	46	44	1.0085	42¼	47¾	1.0068	39	51	1.0083	36¼	53¾	1.0065	34	56
1.010-15	1.0132	69	21	1.0130	54¾	35¼	1.0140	49½	40½	1.0114	46¼	43¾	1.0135	42½	47½	1.0123	39¼	50¾	1.0144	36½	53½	1.0130	34¼	55¾
1.015-20	1.0198	70	20	1.0160	55	35	1.0178	49¾	40¼	1.0156	46½	43½	1.0183	42¾	47¼	1.0177	39½	50½				1.0195	34½	55½
1.020-25	1.0230	70½	19½	1.0222	55½	34½	1.0215	50	40	1.0240	47	43	1.0230	43	47	1.0231	39¾	50¼	1.0203	36¾	53¼			
1.025-30	1.0261	71	19	1.0252	55¾	34¼	1.0288	50½	39½	1.0282	47¼	42¾	1.0287	43¼	46¾	1.0284	40	50	1.0263	37	53	1.0260	34¾	55¼
1.030-35	1.0322	72	18	1.0342	56½	33½	1.0326	50¾	39¼	1.0323	47½	42½	1.0323	43½	46½	1.0337	40¼	49¾	1.0323	37¼	52¾	1.0324	35	55
1.035-40	1.0350	72½	17½	1.0371	56¾	33¼	1.0362	51	39	1.0364	47¾	42¼	1.0371	43¾	46¼	1.0391	40½	49½	1.0382	37½	52½	1.0388	35¼	54¾
1.040-45	1.0432	74	16	1.0404	57	33	1.0435	51½	38½	1.0405	48	42	1.0419	44	46	1.0443	40¾	49¼	1.0440	37¾	52¼			
1.045-50	1.0482	75	15	1.0461	57½	32½	1.0471	51¾	38¼	1.0486	48½	41½	1.0466	44¼	45¾	1.0496	41	49				1.0452	35½	54½

LEADS FROM 1.050 TO 1.2

Approximate Lead	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.050-55	1.0518	58	32	1.0508	52	38	1.0527	48¾	41¼	1.0513	44½	45½	1.0549	41¼	48¾	1.0500	38	52	1.0515	35¾	54¼	1.0527	33¼	56¾
1.055-60	1.0575	58½	31½	1.0577	52½	37½	1.0567	49	41	1.0559	44¾	45¼				1.0558	38¼	51¾	1.0579	36	54	1.0597	33½	56½
1.060-65	1.0632	59	31	1.0613	52¾	37¼	1.0646	49½	40½	1.0606	45	45	1.0601	41½	48½	1.0617	38½	51½	1.0642	36¼	53¾			
1.065-70	1.0685	59½	30½	1.0650	53	37	1.0685	49¾	40¼	1.0698	45½	44½	1.0653	41¾	48¼	1.0674	38¾	51¼				1.0667	33¾	56¼
1.070-75	1.0740	60	30	1.0720	53½	36½	1.0725	50	40	1.0744	45¾	44¼	1.0706	42	48	1.0732	39	51	1.0706	36½	53½	1.0736	34	56
1.075-80	1.0795	60½	29½	1.0788	54	36	1.0764	50¼	39¾	1.0790	46	44	1.0758	42¼	47¾	1.0790	39¼	50¾	1.0769	36¾	53¼			
1.080-85	1.0848	61	29	1.0822	54¼	35¾	1.0803	50½	39½	1.0835	46¼	43¾	1.0809	42½	47½	1.0848	39½	50½	1.0832	37	53	1.0805	34¼	55¾
1.085-90	1.0871	61¼	28¾	1.0856	54½	35½	1.0880	51	39	1.0879	46½	43½	1.0861	42¾	47¼				1.0895	37¼	52¾	1.0874	34½	55½
1.090-95	1.0900	61½	28½	1.0923	55	35	1.0919	51¼	38¾	1.0924	46¾	43¼	1.0911	43	47	1.0906	39¾	50¼				1.0943	34¾	55¼
1.095-00	1.0950	62	28	1.0990	55½	34½	1.0958	51½	38½	1.0969	47	43	1.0963	43¼	46¾	1.0962	40	50	1.0957	37½	52½			
1.100-05	1.1000	62½	27½	1.1022	55¾	34¼	1.1033	52	38	1.1014	47¼	42¾	1.1014	43½	46½	1.1019	40¼	49¾	1.1019	37¾	52¼	1.1012	35	55
1.105-10	1.1050	63	27	1.1055	56	34	1.1070	52¼	37¾	1.1058	47½	42½	1.1063	43¾	46¼	1.1076	40½	49½	1.1081	38	52	1.1080	35¼	54¾
1.110-15	1.1148	64	26	1.1119	56½	33½	1.1107	52½	37½	1.1148	48	42	1.1115	44	46	1.1132	40¾	49¼	1.1142	38¼	51¾	1.1149	35½	54½
1.115-20	1.1195	64½	25½	1.1184	57	33	1.1181	53	37	1.1190	48¼	41¾	1.1163	44¼	45¾	1.1188	41	49						
1.120-25	1.1240	65	25	1.1247	57½	32½	1.1218	53¼	36¾	1.1234	48½	41½	1.1213	44½	45½	1.1244	41¼	48¾	1.1204	38½	51½	1.1217	35¾	54¼
1.125-30	1.1286	65½	24½	1.1278	57¾	32¼	1.1254	53½	36½	1.1277	48¾	41¼	1.1262	44¾	45¼				1.1266	38¾	51¼	1.1285	36	54
1.130-35	1.1330	66	24	1.1308	58	32	1.1327	54	36	1.1320	49	41	1.1313	45	45	1.1300	41½	48½	1.1327	39	51			
1.135-40	1.1375	66½	23½	1.1369	58½	31½	1.1398	54½	35½	1.1363	49¼	40¾	1.1362	45¼	44¾	1.1357	41¾	48¼	1.1388	39¼	50¾	1.1352	36¼	53¾
1.140-45	1.1417	67	23	1.1430	59	31	1.1433	54¾	35¼	1.1405	49½	40½	1.1411	45½	44½	1.1412	42	48	1.1449	39½	50½	1.1420	36½	53½
1.145-50	1.1459	67½	22½	1.1489	59½	30½	1.1468	55	35	1.1490	50	40	1.1460	45¾	44¼	1.1467	42¼	47¾				1.1487	36¾	53¼
1.150-55	1.1500	68	22	1.1548	60	30	1.1538	55½	34½	1.1532	50¼	39¾	1.1508	46	44	1.1522	42½	47½	1.1510	39¾	50¼			
1.155-60	1.1598	69¼	20¾	1.1578	60¼	29¾	1.1572	55¾	34¼	1.1573	50½	39½	1.1557	46¼	43¾	1.1578	42¾	47¼	1.1570	40	50	1.1554	37	53
1.160-65	1.1618	69½	20½	1.1606	60½	29½	1.1607	56	34	1.1615	50¾	39¼	1.1606	46½	43½	1.1631	43	47	1.1629	40¼	49¾	1.1621	37¼	52¾
1.165-70	1.1655	70	20	1.1662	61	29	1.1674	56½	33½	1.1656	51	39	1.1654	46¾	43¼	1.1685	43¼	46¾	1.1689	40½	49½	1.1687	37½	52½
1.170-75	1.1727	71	19	1.1718	61½	28½	1.1742	57	33	1.1738	51½	38½	1.1700	47	43	1.1738	43½	46½	1.1749	40¾	49¼			
1.175-80	1.1761	71½	18½	1.1775	62	28	1.1774	57¼	32¾	1.1778	51¾	38¼	1.1795	47½	42½	1.1792	43¾	46¼				1.1753	37¾	52¼
1.180-85	1.1829	72½	17½	1.1828	62½	27	1.1808	57½	32½	1.1819	52	38	1.1841	47¾	42¼	1.1847	44	46	1.1808	41	49	1.1820	38	52
1.185-90	1.1860	73	17	1.1881	63	27	1.1871	58	32	1.1861	52¼	37¾	1.1891	48	42				1.1867	41¼	48¾	1.1887	38¼	51¾
1.190-95	1.1922	74	16	1.1934	63½	26½	1.1936	58½	31½	1.1900	52½	37½	1.1935	48¼	41¾	1.1900	44¼	45¾	1.1926	41½	48½			
1.195-00	1.1980	75	15	1.1986	64	26	1.1968	58¾	31¼	1.1980	53	37	1.1981	48½	41½	1.1953	44½	45½	1.1985	41¾	48¼	1.1951	38½	51½

LEADS FROM 1.200 TO 1.350

Approximate Lead	Gear on Worm 24, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.200-05	1.2000	59	31	1.2018	53¼	36¾	1.2029	48¾	41¼	1.2007	44¾	45¼
1.205-10	1.2062	59½	30½	1.2058	53½	36½	1.2075	49	41	1.2060	45	45
1.210-15	1.2124	60	30	1.2135	54	36	1.2120	49¼	40¾	1.2112	45¼	44¾
1.215-20	1.2185	60½	29½	1.2172	54¼	35¾	1.2165	49½	40½	1.2163	45½	44½
1.220-25	1.2245	61	29	1.2210	54½	35½	1.2211	49¾	40¼	1.2216	45¾	44¼
1.225-30	1.2274	61¼	28¾	1.2287	55	35	1.2256	50	40	1.2268	46	44
1.230-35	1.2302	61½	28½	1.2324	55¼	34¾	1.2345	50½	39½	1.2319	46¼	43¾
1.235-40	1.2362	62	28	1.2362	55½	34½	1.2389	50¾	39¼	1.2370	46½	43½
1.240-45	1.2418	62½	27½	1.2435	56	34	1.2435	51	39	1.2421	46¾	43¼
1.245-50	1.2474	63	27	1.2470	56¼	33¾	1.2474	51¼	38¾	1.2472	47	43
1.250-55	1.2529	63½	26½	1.2506	56½	33½	1.2521	51½	38½	1.2523	47¼	42¾
1.255-60	1.2584	64	26	1.2580	57	33	1.2563	51¾	38¼	1.2573	47½	42½
1.260-65	1.2636	64½	25½	1.2614	57¼	32¾	1.2607	52	38	1.2623	47¾	42¼
1.265-70	1.2689	65	25	1.2655	57½	32½	1.2694	52½	37½	1.2675	48	42
1.270-75	1.2739	65½	24½	1.2718	58	32	1.2736	52¾	37¼	1.2722	48¼	41¾
1.275-80	1.2790	66	24	1.2788	58½	31½	1.2778	53	37	1.2772	48½	41½
1.280-85	1.2840	66½	23½	1.2821	58¾	31¼	1.2820	53¼	36¾	1.2822	48¾	41¼
1.285-90	1.2887	67	23	1.2858	59	31	1.2861	53½	36½	1.2870	49	41
1.290-95	1.2934	67½	22½	1.2923	59½	30½	1.2902	53¾	36¼	1.2920	49¼	40¾
1.295-00	1.2980	68	22	1.2989	60	30	1.2943	54	36	1.2968	49½	40½
1.300-05	1.3025	68½	21½	1.3021	60¼	29¾	1.3024	54½	35½	1.3017	49¾	40¼
1.305-10	1.3069	69	21	1.3055	60½	29½	1.3065	54¾	35¼	1.3063	50	40
1.310-15	1.3112	69½	20½	1.3118	61	29	1.3105	55	35	1.3111	50¼	39¾
1.315-20	1.3155	70	20	1.3180	61½	28½	1.3185	55½	34½	1.3160	50½	39½
1.320-25	1.3237	71	19	1.3244	62	28	1.3224	55¾	34¼	1.3207	50¾	39¼
1.325-30	1.3276	71½	18½	1.3275	62¼	27¾	1.3262	56	34	1.3252	51	39
1.330-35	1.3315	72	18	1.3304	62½	27½	1.3340	56½	33½	1.3346	51½	38½
1.335-40	1.3389	73	17	1.3363	63	27	1.3384	56¾	33¼	1.3391	51¾	38¼
1.340-45	1.3424	73½	16½	1.3423	63½	26½	1.3419	57	33	1.3439	52	38
1.345-50	1.3458	74	16	1.3481	64	26	1.3493	57¼	32¾	1.3487	52¼	37¾

Approximate Lead	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 56, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.200-05	1.2043	42	48	1.2017	38¾	51¼	1.2032	36¼	53¾			
1.205-10				1.2082	39	51				1.2059	33¾	56¼
1.210-15	1.2102	42¼	47¾	1.2149	39¼	50¾	1.2104	36½	53½	1.2138	34	56
1.215-20	1.2160	42½	47½				1.2175	36¾	53¼			
1.220-25	1.2219	42¾	47¼	1.2212	39½	50½	1.2246	37	53	1.2216	34¼	55¾
1.225-30	1.2275	43	47	1.2277	39¾	50¼				1.2293	34½	55½
1.230-35	1.2344	43¼	46¾	1.2340	40	50	1.2318	37¼	52¾			
1.235-40	1.2388	43½	46½				1.2388	37½	52½	1.2371	34¾	55¼
1.240-45	1.2445	43¾	46¼	1.2404	40¼	49¾				1.2449	35	55
1.245-50	1.			1.2469	40½	49½	1.2458	37¾	52¼			
1.250-55	1.2502	44	46	1.2532	40¾	49¼	1.2528	38	52	1.2527	35¼	54¾
1.255-60	1.2559	44¼	45¾	1.2595	41	49	1.2598	38¼	51¾			
1.260-65	1.2615	44½	45½							1.2604	35½	54½
1.265-70	1.2671	44¾	45¼	1.2659	41¼	48¾	1.2668	38½	51½	1.2680	35¾	54¼
1.270-75	1.2727	45	45	1.2721	41½	48½	1.2737	38¾	51¼			
1.275-80	1.2783	45¼	44¾	1.2784	41¾	48¼				1.2758	36	54
1.280-85	1.2838	45½	44½	1.2847	42	48	1.2805	39	51	1.2833	36¼	53¾
1.285-90	1.2892	45¾	44¼				1.2875	39¼	50¾			
1.290-95	1.2947	46	44	1.2909	42¼	47¾	1.2943	39½	50½	1.2910	36½	53½
1.295-00				1.2976	42½	47½				1.2986	36¾	53¼
1.300-05	1.3001	46¼	43¾	1.3034	42¾	47¼	1.3012	39¾	50¼			
1.305-10	1.3055	46½	43½	1.3093	43	47	1.3080	40	50	1.3062	37	53
1.310-15	1.3110	46¾	43¼				1.3147	40¼	49¾	1.3138	37¼	52¾
1.315-20	1.3163	47	43	1.3167	43¼	46¾						
1.320-25	1.3217	47¼	42¾	1.3213	43½	46½	1.3216	40½	49½	1.3212	37½	52½
1.325-30	1.3270	47½	42½	1.3275	43¾	46¼	1.3283	40¾	49¼	1.3278	37¾	52¼
1.330-35	1.3322	47¾	42¼	1.3337	44	46						
1.335-40	1.3377	48	42	1.3396	44¼	45¾	1.3350	41	49	1.3362	38	52
1.340-45	1.3427	48¼	41¾				1.3417	41¼	48¾	1.3437	38¼	51¾
1.345-50	1.3480	48½	41½	1.3456	44½	45½	1.3483	41½	48½			

Approximate Lead	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.350-55	1.3530	57¾	32¼	1.3530	52½	37½	1.3533	48¾	41¼	1.3512	44¾	45¼
1.355-60	1.3570	58	32	1.3576	52¾	37¼	1.3583	49	41	1.3576	45	45
1.360-65	1.3641	58½	31½	1.3620	53	37	1.3635	49¼	40¾	1.3635	45¼	44¾
1.365-70	1.3676	58¾	31¼	1.3665	53¼	36¾	1.3686	49½	40½	1.3693	45½	44½
1.370-75	1.3713	59	31	1.3710	53½	36½	1.3738	49¾	40¼			
1.375-80	1.3784	59½	30½	1.3798	54	36	1.3788	50	40	1.3751	45¾	44¼
1.380-85	1.3819	59¾	30¼	1.3840	54¼	35¾	1.3838	50¼	39¾	1.3810	46	44
1.385-90	1.3855	60	30	1.3883	54½	35½	1.3888	50½	39½	1.3868	46¼	43¾
1.390-95	1.3925	60½	29½	1.3927	54¾	35¼	1.3938	50¾	39¼	1.3925	46½	43½
1.395-00	1.3992	61	29	1.3970	55	35	1.3987	51	39	1.3983	46¾	43¼
1.400-05	1.4025	61¼	28¾	1.4012	55¼	34¾	1.4036	51¼	38¾	1.4040	47	43
1.405-10	1.4059	61½	28½	1.4055	55½	34½	1.4085	51½	38½	1.4098	47¼	42¾
1.410-15	1.4128	62	28	1.4139	56	34	1.4134	51¾	38¼			
1.415-20	1.4190	62½	27½	1.4180	56¼	33¾	1.4182	52	38	1.4155	47½	42½
1.420-25	1.4223	62¾	27¼	1.4220	56½	33½	1.4233	52¼	37¾	1.4212	47¾	42¼
1.425-30	1.4254	63	27	1.4267	56¾	33¼	1.4280	52½	37½	1.4267	48	42
1.430-35	1.4318	63½	26½	1.4304	57	33	1.4328	52¾	37¼	1.4322	48¼	41¾
1.435-40	1.4380	64	26	1.4385	57½	32½	1.4375	53	37	1.4379	48½	41½
1.440-45	1.4441	64½	25½	1.4423	57¾	32¼	1.4422	53¼	36¾	1.4435	48¾	41¼
1.445-50	1.4499	65	25	1.4462	58	32	1.4469	53½	36½	1.4490	49	41
1.450-55	1.4529	65¼	24¾	1.4540	58½	31½	1.4515	53¾	36¼	1.4544	49¼	40¾
1.455-60	1.4558	65½	24½	1.4579	58¾	31¼	1.4561	54	36	1.4599	49½	40½
1.460-65	1.4617	66	24	1.4619	59	31	1.4607	54¼	35¾			
1.465-70	1.4672	66½	23½	1.4693	59½	30½	1.4652	54½	35½	1.4652	49¾	40¼
1.470-75	1.4726	67	23	1.4731	59¾	30¼	1.4745	55	35	1.4707	50	40
1.475-80	1.4780	67½	22½	1.4769	60	30	1.4789	55¼	34¾	1.4760	50¼	39¾
1.480-85	1.4835	68	22	1.4844	60½	29½	1.4833	55½	34½	1.4813	50½	39½
1.485-90	1.4885	68½	21½	1.4879	60¾	29¼	1.4877	55¾	34¼	1.4867	50¾	39¼
1.490-95	1.4938	69	21	1.4916	61	29	1.4921	56	34	1.4919	51	39
1.495-00	1.4988	69½	20½	1.4987	61½	28½	1.4964	56¼	33¾	1.4972	51¼	38¾

Approximate Lead	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 56, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.350-55				1.3511	38½	51½				1.3522	33½	56½
1.355-60	1.3550	41¾	48¼	1.3585	38¾	51¼	1.3550	36¼	53¾			
1.360-65	1.3617	42	48				1.3630	36½	53½	1.3611	33¾	56¼
1.365-70	1.3682	42¼	47¾	1.3659	39	51						
1.370-75	1.3748	42½	47½	1.3732	39¼	50¾	1.3710	36¾	53¼	1.3700	34	56
1.375-80							1.3790	37	53	1.3789	34¼	55¾
1.380-85	1.3815	42¾	47¼	1.3806	39½	50½						
1.385-90	1.3878	43	47	1.3880	39¾	50¼	1.3870	37¼	52¾	1.3877	34½	55½
1.390-95												
1.395-00	1.3956	43¼	46¾	1.3951	40	50	1.3950	37½	52½	1.3964	34¾	55¼
1.400-05	1.4005	43½	46½	1.4023	40¼	49¾	1.4029	37¾	52¼			
1.405-10	1.4071	43¾	46¼	1.4096	40½	49½				1.4052	35	55
1.410-15	1.4135	44	46				1.4108	38	52	1.4140	35¼	54¾
1.415-20	1.4199	44¼	45¾	1.4168	40¾	49¼	1.4187	38¼	51¾			
1.420-25				1.4239	41	49				1.4227	35½	54½
1.425-30	1.4262	44½	45½				1.4265	38½	51½			
1.430-35	1.4326	44¾	45¼	1.4310	41¼	48¾	1.4342	38¾	51¼	1.4313	35¾	54¼
1.435-40	1.4389	45	45	1.4381	41½	48½						
1.440-45							1.4420	39	51	1.4400	36	54
1.445-50	1.4451	45¼	44¾	1.4452	41¾	48¼	1.4499	39¼	50¾	1.4487	36¼	53¾
1.450-55	1.4513	45½	44½	1.4523	42	48						
1.455-60	1.4576	45¾	44¼	1.4593	42¼	47¾	1.4576	39½	50½	1.4572	36½	53½
1.460-65	1.4637	46	44									
1.465-70	1.4699	46¼	43¾	1.4673	42½	47½	1.4652	39¾	50¼	1.4658	36¾	53¼
1.470-75				1.4735	42¾	47¼	1.4730	40	50	1.4743	37	53
1.475-80	1.4759	46½	43½									
1.480-85	1.4821	46¾	43¼	1.4802	43	47	1.4805	40¼	49¾	1.4829	37¼	52¾
1.485-90	1.4881	47	43	1.4886	43¼	46¾	1.4882	40½	49½			
1.490-95	1.4942	47¼	42¾							1.4914	37½	52½
1.495-00				1.4958	43½	46½	1.4958	40¾	49¼	1.4999	37¾	52¼

LEADS FROM 1.500 TO 1.650

Approximate Lead	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	24	72	44	86	Degrees	Degrees	24	64	48	100	Degrees	Degrees
1.500-05	1.5025				61¾	28¼	1.5008				56½	33½
1.505-10	1.5069				62	28	1.5096				57	33
1.510-15	1.5127				62½	27½	1.5137				57¼	32¾
1.515-20	1.5196				63	27	1.5180				57½	32½
1.520-25	1.5230				63¼	26¾	1.5221				57¾	32¼
1.525-30	1.5261				63½	26½	1.5262				58	32
1.530-35	1.5329				64	26	1.5345				58½	31½
1.535-40	1.5393				64½	25½	1.5386				58¾	31¼
1.540-45	1.5425				64¾	25¼	1.5428				59	31
1.545-50	1.5456				65	25	1.5468				59¼	30¾
1.550-55	1.5519				65½	24½	1.5506				59½	30½
1.555-60	1.5580				66	24	1.5588				60	30
1.560-65	1.5640				66½	23½	1.5626				60¼	29¾
1.565-70	1.5698				67	23	1.5665				60½	29½
1.570-75	1.5727				67¼	22¾	1.5741				61	29
1.575-80	1.5755				67½	22½	1.5779				61¼	28¾
1.580-85	1.5810				68	22	1.5816				61½	28½
1.585-90	1.5877				68½	21½	1.5893				62	28
1.590-95	1.5920				69	21	1.5929				62¼	27¾
1.595-00	1.5973				69½	20½	1.5964				62½	27½
1.600-05	1.6025				70	20	1.6037				63	27
1.605-10	1.6075				70½	19½	1.6074				63¼	26¾
1.610-15	1.6125				71	19	1.6108				63½	26½
1.615-20	1.6172				71½	18½	1.6178				64	26
1.620-25	1.6220				72	18	1.6246				64½	25½
1.625-30	1.6264				72½	17½	1.6279				64¾	25¼
1.630-35	1.6309				73	17	1.6311				65	25
1.635-40	1.6393				74	16	1.6379				65½	24½
1.640-45	1.6433				74½	15½	1.6442				66	24
1.645-50	1.6471				75	15	1.6474				66¼	23¾

Approximate Lead	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	24	40	32	100	Degrees	Degrees	28	64	40	86	Degrees	Degrees
1.500-05	1.5025				51½	38½	1.5002				47½	42½
1.505-10	1.5076				51¾	38¼	1.5061				47¾	42¼
1.510-15	1.5128				52	38	1.5124				48	42
1.515-20	1.5181				52¼	37¾	1.5181				48¼	41¾
1.520-25	1.5232				52½	37½	1.5240				48½	41½
1.525-30	1.5283				52¾	37¼						
1.530-35	1.5334				53	37	1.5300				48¾	41¼
1.535-40	1.5383				53¼	36¾	1.5357				49	41
1.540-45	1.5433				53½	36½	1.5416				49¼	40¾
1.545-50	1.5488				53¾	36¼	1.5472				49½	40½
1.550-55	1.5532				54	36	1.5531				49¾	40¼
1.555-60	1.5580				54¼	35¾	1.5588				50	40
1.560-65	1.5630				54½	35½	1.5645				50¼	39¾
1.565-70	1.5678				54¾	35¼						
1.570-75	1.5726				55	35	1.5700				50½	39½
1.575-80	1.5774				55¼	34¾	1.5758				50¾	39¼
1.580-85	1.5822				55½	34½	1.5812				51	39
1.585-90	1.5869				55¾	34¼	1.5869				51¼	38¾
1.590-95	1.5916				56	34	1.5925				51½	38½
1.595-00	1.5962				56¼	33¾	1.5979				51¾	38¼
1.600-05	1.6009				56½	33½	1.6024				52	38
1.605-10	1.6060				56¾	33¼	1.6091				52¼	37¾
1.610-15	1.6102				57	33	1.6145				52½	37½
1.615-20	1.6192				57½	32½	1.6199				52¾	37¼
1.620-25	1.6237				57¾	32¼						
1.625-30	1.6280				58	32	1.6252				53	37
1.630-35	1.6325				58¼	31¾	1.6305				53¼	36¾
1.635-40	1.6369				58½	31½	1.6358				53½	36½
1.640-45	1.6411				58¾	31¼	1.6410				53¾	36¼
1.645-50	1.6457				59	31	1.6462				54	36

Approximate Lead	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	24	72	56	86	Degrees	Degrees	24	64	44	72	Degrees	Degrees
1.500-05	1.5009				43¾	46¼	1.5033				41	49
1.505-10	1.5077				44	46						
1.510-15	1.5145				44¼	45¾	1.5109				41¼	48¾
1.515-20							1.5183				41½	48½
1.520-25	1.5212				44½	45½						
1.525-30	1.5280				44¾	45¼	1.5259				41¾	48¼
1.530-35	1.5348				45	45	1.5333				42	48
1.535-40												
1.540-45	1.5414				45¼	44¾	1.5408				42¼	47¾
1.545-50	1.5480				45½	44½	1.5481				42½	47½
1.550-55	1.5546				45¾	44¼						
1.555-60							1.5558				42¾	47¼
1.560-65	1.5612				46	44	1.5628				43	47
1.565-70	1.5678				46¼	43¾						
1.570-75	1.5742				46½	43½	1.5716				43¼	46¾
1.575-80							1.5771				43½	46½
1.580-85	1.5808				46¾	43¼	1.5845				43¾	46¼
1.585-90	1.5873				47	43						
1.590-95	1.5938				47¼	42¾	1.5918				44	46
1.595-00							1.5990				44¼	45¾
1.600-05	1.6002				47½	42½						
1.605-10	1.6065				47¾	42¼	1.6061				44½	45½
1.610-15	1.6131				48	42	1.6131				44¾	45¼
1.615-20	1.6192				48¼	41¾						
1.620-25							1.6204				45	45
1.625-30	1.6254				48½	41½	1.6274				45¼	44¾
1.630-35	1.6319				48¾	41¼	1.6345				45½	44½
1.635-40	1.6380				49	41						
1.640-45	1.6442				49¼	40¾	1.6413				45¾	44¼
1.645-50							1.6483				46	44

Approximate Lead	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm	1st on Stud	2nd on Stud	Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	28	64	56	100	Degrees	Degrees	40	86	56	100	Degrees	Degrees
1.500-05							1.5034				35¼	54¾
1.505-10	1.5083				38	52	1.5127				35½	54½
1.510-15												
1.515-20	1.5167				38¼	51¾						
1.520-25							1.5219				35¾	54¼
1.525-30	1.5251				38½	51½						
1.530-35	1.5334				38¾	51¼	1.5311				36	54
1.535-40												
1.540-45	1.5418				39	51	1.5402				36¼	53¾
1.545-50							1.5494				36½	53½
1.550-55	1.5500				39¼	50¾						
1.555-60	1.5583				39½	50½	1.5585				36¾	53¼
1.560-65												
1.565-70	1.5666				39¾	50¼	1.5677				37	53
1.570-75	1.5748				40	50						
1.575-80							1.5767				37¼	52¾
1.580-85	1.5829				40¼	49¾						
1.585-90							1.5857				37½	52½
1.590-95	1.5911				40½	49½	1.5948				37¾	52¼
1.595-00	1.5991				40¾	49¼						
1.600-05							1.6038				38	52
1.605-10	1.6073				41	49						
1.610-15							1.6127				38¼	51¾
1.615-20	1.6153				41¼	48¾						
1.620-25	1.6233				41½	48½	1.6216				38½	51½
1.625-30												
1.630-35	1.6313				41¾	48¼	1.6304				38¾	51¼
1.635-40	1.6392				42	48	1.6392				39	51
1.640-45												
1.645-50	1.6472				42¼	47¾	1.6481				39¼	50¾

LEADS FROM 1.650 TO [illegible]

Approximate Lead	Gear on Worm 24, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 56, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.650-55	1.6541	59½	30½	1.6514	54¼	35¾	1.6503	49½	40½			
1.655-60	1.6582	59¾	30¼	1.6566	54½	35½	1.6565	49¾	40¼	1.6553	46¼	43¾
1.660-65	1.6625	60	30	1.6617	54¾	35¼	1.6627	50	40	1.6620	46½	43½
1.665-70	1.6667	60¼	29¾	1.6669	55	35	1.6687	50¼	39¾	1.6690	46¾	43¼
1.670-75	1.6710	60½	29½	1.6720	55¼	34¾	1.6748	50½	39½			
1.675-80	1.6791	61	29	1.6771	55½	34½				1.6759	47	43
1.680-85	1.6831	61¼	28¾	1.6820	55¾	34¼	1.6808	50¾	39¼	1.6827	47¼	42¾
1.685-90	1.6870	61½	28½	1.6870	56	34	1.6866	51	39	1.6895	47½	42½
1.690-95	1.6912	61¾	28¼	1.6919	56¼	33¾	1.6927	51¼	38¾			
1.695-00	1.6952	62	28	1.6968	56½	33½	1.6985	51½	38½	1.6960	47¾	42¼
1.700-05	1.7029	62½	27½	1.7023	56¾	33¼	1.7044	51¾	38¼	1.7031	48	42
1.705-10	1.7068	62¾	27¼	1.7068	57	33				1.7095	48¼	41¾
1.710-15	1.7106	63	27	1.7112	57¼	32¾	1.7103	52	38			
1.715-20	1.7181	63½	26½	1.7162	57½	32½	1.7164	52¼	37¾	1.7160	48½	41½
1.720-25	1.7220	63¾	26¼	1.7209	57¾	32¼	1.7220	52½	37½	1.7230	48¾	41¼
1.725-30	1.7257	64	26	1.7255	58	32	1.7278	52¾	37¼	1.7294	49	41
1.730-35	1.7329	64½	25½	1.7349	58½	31½	1.7334	53	37			
1.735-40	1.7399	65	25	1.7395	58¾	31¼	1.7390	53¼	36¾	1.7360	49¼	40¾
1.740-45	1.7434	65¼	24¾	1.7442	59	31	1.7448	53½	36½	1.7424	49½	40½
1.745-50	1.7470	65½	24½	1.7488	59¼	30¾				1.7490	49¾	40¼
1.750-55	1.7539	66	24	1.7531	59½	30½	1.7503	53¾	36¼			
1.755-60	1.7571	66¼	23¾	1.7578	59¾	30¼	1.7560	54	36	1.7553	50	40
1.760-65	1.7608	66½	23½	1.7621	60	30	1.7614	54¼	35¾	1.7618	50¼	39¾
1.765-70	1.7671	67	23	1.7667	60¼	29¾	1.7670	54½	35½	1.7681	50½	39½
1.770-75	1.7737	67½	22½	1.7711	60½	29½	1.7725	54¾	35¼	1.7745	50¾	39¼
1.775-80	1.7771	67¾	22¼	1.7799	61	29	1.7779	55	35			
1.780-85	1.7800	68	22	1.7840	61¼	28¾	1.7833	55¼	34¾	1.7808	51	39
1.785-90	1.7862	68½	21½	1.7881	61½	28½	1.7888	55½	34½	1.7871	51¼	38¾
1.790-95	1.7922	69	21	1.7925	61¾	28¼	1.7940	55¾	34¼	1.7933	51½	38½
1.795-00	1.7981	69½	20½	1.7969	62	28	1.7993	56	34	1.7996	51¾	38¼

Approximate Lead	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 86, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 56, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.650-55							1.6523	36½	53½			
1.655-60	1.6551	42½	47½	1.6570	39½	50½				1.6581	34¼	55¾
1.660-65	1.6632	42¾	47¼				1.6620	36¾	53¼			
1.665-70				1.6657	39¾	50¼				1.6688	34½	55½
1.670-75	1.6708	43	47	1.6743	40	50	1.6718	37	53			
1.675-80										1.6793	34¾	55¼
1.680-85	1.6803	43¼	46¾	1.6830	40¼	49¾	1.6814	37¼	52¾			
1.685-90	1.6861	43½	46½							1.6899	35	55
1.690-95	1.6940	43¾	46¼	1.6918	40½	49½	1.6911	37½	52½			
1.695-00												
1.700-05	1.7019	44	46	1.7003	40¾	49¼	1.7006	37¾	52¼	1.7004	35¼	54¾
1.705-10	1.7094	44¼	45¾	1.7090	41	49						
1.710-15							1.7102	38	52	1.7109	35½	54½
1.715-20	1.7171	44½	45½	1.7175	41¼	48¾	1.7198	38¼	51¾			
1.720-25	1.7248	44¾	45¼							1.7211	35¾	54¼
1.725-30				1.7260	41½	48½	1.7292	38½	51½			
1.730-35	1.7324	45	45	1.7345	41¾	48¼				1.7317	36	54
1.735-40	1.7399	45¼	44¾				1.7388	38¾	51¼			
1.740-45				1.7430	42	48				1.7420	36¼	53¾
1.745-50	1.7474	45½	44½				1.7481	39	51			
1.750-55	1.7549	45¾	44¼	1.7515	42¼	47¾				1.7524	36½	53½
1.755-60				1.7599	42½	47½	1.7575	39¼	50¾			
1.760-65	1.7623	46	44							1.7627	36¾	53¼
1.765-70	1.7697	46¼	43¾				1.7670	39½	50½			
1.770-75				1.7684	42¾	47½				1.7730	37	53
1.775-80	1.7770	46½	43½	1.7765	43	47	1.7763	39¾	50¼			
1.780-85	1.7849	46¾	43¼							1.7833	37¼	52¾
1.785-90				1.7866	43¼	46¾	1.7857	40	50			
1.790-95	1.7918	47	43				1.7949	40¼	49¾	1.7935	37½	52½
1.795-00	1.7990	47¼	42¾	1.7962	43½	46½						

LEADS FROM 1.800 TO 1.950

Approximate Lead	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 88	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 56, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 86, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 56, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.800-05	1.8049	62½	27½	1.8046	56¼	33¾							1.8012	43¾	46¼	1.8041	40½	49½	1.8038	37¾	52¼	1.8008	35	55
1.805-10	1.8090	62¾	27¼	1.8099	56½	33½	1.8058	52	38	1.8063	47½	42½	1.8095	44	46									
1.810-15	1.8130	63	27				1.8121	52¼	37¾	1.8133	47¾	42¼				1.8132	40¾	49¼	1.8140	38	52	1.8120	35¼	54¾
1.815-20	1.8172	63¼	26¾	1.8157	56¾	33¼	1.8181	52½	37½				1.8176	44¼	45¾									
1.820-25	1.8211	63½	26½	1.8204	57	33	1.8242	52¾	37¼	1.8209	48	42				1.8224	41	49	1.8241	38¼	51¾	1.8231	35½	54½
1.825-30	1.8290	64	26	1.8254	57¼	32¾				1.8278	48¼	41¾	1.8258	44½	45½									
1.830-35	1.8329	64¼	25¾	1.8307	57½	32½	1.8301	53	37	1.8348	48½	41½	1.8339	44¾	45¼	1.8316	41¼	48¾	1.8341	38½	51½	1.8342	35¾	54¼
1.835-40	1.8368	64½	25½	1.8355	57¾	32¼	1.8361	53¼	36¾															
1.840-45	1.8441	65	25	1.8405	58	32	1.8421	53½	36½	1.8420	48¾	41¼	1.8420	45	45	1.8407	41½	48½	1.8441	38¾	51¼			
1.845-50	1.8479	65¼	24¾	1.8455	58¼	31¾	1.8480	53¾	36¼	1.8490	49	41				1.8498	41¾	48¼				1.8453	36	54
1.850-55	1.8517	65½	24½	1.8505	58½	31½	1.8540	54	36				1.8500	45¼	44¾				1.8541	39	51			
1.855-60	1.8590	66	24	1.8555	58¾	31¼	1.8598	54¼	35¾	1.8560	49¼	40¾	1.8580	45½	44½	1.8588	42	48				1.8563	36¼	53¾
1.860-65	1.8625	66¼	23¾	1.8605	59	31				1.8629	49½	40½							1.8642	39¼	50¾			
1.865-70	1.8661	66½	23½	1.8699	59½	30½	1.8655	54½	35½	1.8690	49¾	40¼	1.8659	45¾	44¼	1.8678	42¼	47¾				1.8674	36½	53½
1.870-75	1.8730	67	23	1.8748	59¾	30¼	1.8713	54¾	35¼				1.8737	46	44				1.8742	39½	50½			
1.875-80	1.8765	67¼	22¾	1.8797	60	30	1.8770	55	35	1.8768	50	40				1.8768	42½	47½				1.8784	36¾	53¼
1.880-85	1.8800	67½	22½	1.8845	60¼	29¾	1.8829	55¼	34¾	1.8836	50¼	39¾	1.8817	46¼	43¾				1.8841	39¾	50¼			
1.885-90	1.8867	68	22	1.8891	60½	29½	1.8887	55½	34½				1.8894	46½	43½	1.8859	42¾	47¼				1.8894	37	53
1.890-95	1.8932	68½	21½	1.8936	60¾	29¼	1.8941	55¾	34¼	1.8904	50½	39½				1.8945	43	47	1.8939	40	50			
1.895-00	1.8997	69	21	1.8982	61	29	1.8998	56	34	1.8972	50¾	39¼	1.8973	46¾	43¼									
1.900-05	1.9029	69¼	20¾	1.9028	61¼	28¾				1.9038	51	39							1.9035	40¼	49¾	1.9004	37¼	52¾
1.905-10	1.9060	69½	20½	1.9071	61½	28½	1.9053	56¼	33¾				1.9052	47	43	1.9052	43¼	46¾						
1.910-15	1.9122	70	20	1.9120	61¾	28¼	1.9109	56½	33½	1.9106	51¼	38¾	1.9129	47¼	42¾	1.9123	43½	46½	1.9135	40½	49½	1.9113	37½	52½
1.915-20	1.9181	70½	19½	1.9166	62	28	1.9170	56¾	33¼	1.9172	51½	38½												
1.920-25	1.9240	71	19	1.9210	62¼	27¾	1.9219	57	33	1.9239	51¾	38¼	1.9205	47½	42½	1.9210	43¾	46¼	1.9232	40¾	49¼	1.9221	37¾	52¼
1.925-30	1.9298	71½	18½	1.9251	62½	27½	1.9271	57¼	32¾				1.9280	47¾	42¼	1.9297	44	46						
1.930-35	1.9326	71¾	18¼	1.9338	63	27	1.9328	57½	32½	1.9305	52	38												
1.935-40	1.9355	72	18	1.9382	63¼	26¾	1.9380	57¾	32¼	1.9373	52¼	37¾	1.9360	48	42	1.9383	44¼	45¾	1.9329	41	49	1.9329	38	52
1.940-45	1.9407	72½	17½	1.9424	63½	26½	1.9431	58	32	1.9438	52½	37½	1.9433	48¼	41¾				1.9426	41¼	48¾	1.9437	38¼	51¾
1.945-50	1.9460	73	17	1.9467	63¾	26¼	1.9485	58¼	31¾							1.9470	44¼	45¾						

LEADS FROM 1.950 TO 2.100

Approximate Lead	Gear on Worm 24, 1st on Stud 72, 2nd on Stud 56, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 64, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 86, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 56, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
1.950-55	1.9509	64	26	1.9538	58½	31½	1.9502	52¾	37¼	1.9511	48½	41½				1.9523	41½	48½	1.9544	38½	51½			
1.955-60	1.9590	64½	25½	1.9590	58¾	31¼	1.9567	53	37	1.9585	48¾	41¼	1.9557	44¾	45¼							1.9592	36	54
1.960-65	1.9630	64¾	25¼	1.9642	59	31	1.9630	53¼	36¾				1.9642	45	45	1.9619	41¾	48¼						
1.965-70	1.9670	65	25	1.9692	59¼	30¾	1.9694	53½	36½	1.9660	49	41							1.9650	38¾	51¼			
1.970-75	1.9710	65¼	24¾	1.9744	59½	30½				1.9734	49¼	40¾	1.9728	45¼	44¾	1.9714	42	48				1.9709	36¼	53¾
1.975-80	1.9750	65½	24½	1.9794	59¾	30¼	1.9758	53¾	36¼										1.9757	39	51			
1.980-85	1.9829	66	24	1.9845	60	30	1.9820	54	36	1.9808	49½	40½	1.9815	45½	44½	1.9810	42¼	47¾				1.9827	36½	53½
1.985-90	1.9865	66¼	23¾	1.9896	60¼	29¾	1.9882	54¼	35¾	1.9881	49¾	40¼	1.9899	45¾	44¼				1.9864	39¼	50¾			
1.990-95	1.9906	66½	23½	1.9945	60½	29½	1.9945	54½	35½							1.9904	42½	47½				1.9943	36¾	53¼
1.995-00	1.9979	67	23	1.9995	60¾	29¼				1.9955	50	40	1.9983	46	44	2.000	42¾	47¼	1.9970	39½	50½			
2.000-05	2.0016	67¼	22¾	2.0041	61	29	2.0007	54¾	35¼	2.0028	50¼	39¾												
2.005-10	2.0051	67½	22½	2.0090	61¼	28¾	2.0069	55	35				2.0066	46¼	43¾	2.0094	43	47	2.0075	39¾	50¼	2.0060	37	53
2.010-15	2.0123	68	22	2.0138	61½	28½	2.0130	55¼	34¾	2.0100	50½	39½	2.0149	46½	43½									
2.015-20	2.0193	68½	21½	2.0187	61¾	28¼	2.0191	55½	34½	2.0172	50¾	39¼				2.0187	43¼	46¾	2.0181	40	50	2.0177	37¼	52¾
2.020-25	2.0229	68¾	21¼	2.0236	62	28				2.0247	51	39	2.0233	46¾	43¼									
2.025-30	2.0264	69	21	2.0280	62¼	27¾	2.0250	55¾	34¼							2.0282	43½	46½	2.0286	40¼	49¾	2.0291	37½	52½
2.030-35	2.0329	69½	20½	2.0325	62½	27½	2.0311	56	34	2.0315	51¼	38¾	2.0319	47	43									
2.035-40	2.0395	70	20	2.0371	62¾	27¼	2.0370	56¼	33¾	2.0386	51½	38½				2.0373	43¾	46¼	2.0390	40½	49½			
2.040-45	2.0428	70¼	19¾	2.0418	63	27	2.0429	56½	33½				2.0400	47¼	42¾							2.0407	37¾	52¼
2.045-50	2.0459	70½	19½	2.0465	63¼	26¾	2.0495	56¾	33¼	2.0456	51¾	38¼	2.0481	47½	42½	2.0467	44	46	2.0494	40¾	49¼			
2.050-55	2.0521	71	19	2.0507	63½	26½	2.0549	57	33	2.0525	52	38										2.0521	38	52
2.055-60	2.0583	71½	18½	2.0598	64	26							2.0561	47¾	42¼	2.0558	44¼	45¾						
2.060-65	2.0644	72	18	2.0640	64¼	25¾	2.0602	57¼	32¾	2.0600	52¼	37¾	2.0643	48	42	2.0651	44½	45½	2.0597	41	49	2.0635	38¼	51¾
2.065-70	2.0672	72¼	17¾	2.0684	64½	25½	2.0663	57½	32½	2.0667	52½	37½												
2.070-75	2.0700	72½	17½	2.0726	64¾	25¼	2.0719	57¾	32¼	2.0736	52¾	37¼	2.0723	48¼	41¾	2.0742	44¾	45¼	2.0700	41¼	48¾	2.0749	38½	51½
2.075-80	2.0757	73	17	2.0768	65	25	2.0774	58	32															
2.080-85	2.0811	73½	16½	2.0810	65¼	24¾	2.0831	58¼	31¾	2.0805	53	37	2.0808	48½	41½	2.0834	45	45	2.0803	41½	48½			
2.085-90	2.0865	74	16	2.0851	65½	24½	2.0889	58½	31½	2.0872	53¼	36¾	2.0886	48¾	41¼							2.0863	38¾	51¼
2.090-95	2.0915	74½	15½	2.0935	66	24										2.0924	45¼	44¾	2.0906	41¾	48¼			
2.095-00	2.0965	75	15	2.0975	66¼	23¾	2.0942	58¾	31¼	2.0940	53½	36½	2.0965	49	41							2.0976	39	51

LEADS FROM 2.100 TO 2.250

Approximate Lead	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	24 64 44 72	Degrees		28 64 56 100	Degrees		40 86 56 100	Degrees		40 56 28 72	Degrees		24 56 44 64	Degrees		24 86 72 64	Degrees		28 56 48 72	Degrees		48 44 28 86	Degrees	
2.100-05	2.1017	66½	23½	2.1000	59	31	2.1007	53¾	36¼	2.1045	49¼	40¾	2.1015	45½	44½	2.1008	42	48				2.1003	36¼	53¾
2.105-10	2.1093	67	23	2.1054	59¼	30¾	2.1075	54	36										2.1090	39¼	50¾			
2.110-15	2.1131	67¼	22¾	2.1108	59½	30½	2.1140	54¼	35¾	2.1122	49½	40½	2.1105	45¾	44¼	2.1109	42¼	46¾	2.1102	39½	50½	2.1127	36½	53½
2.115-20	2.1170	67½	22½	2.1161	59¾	30¼							2.1193	46	44									
2.120-25	2.1246	68	22	2.1216	60	30	2.1207	54½	35½	2.1201	49¾	40¼				2.1210	42½	46½						
2.125-30	2.1284	68¼	21¾	2.1270	60¼	29¾	2.1273	54¾	35¼	2.1280	50	40	2.1283	46¼	43¾							2.1251	36¾	53¼
2.130-35	2.1320	68½	21½	2.1324	60½	29½	2.1339	55	35							2.1311	42¾	46¼	2.1315	39¾	50¼			
2.135-40	2.1392	69	21	2.1375	60¾	29¼				2.1358	50¼	39¾	2.1372	46½	43½							2.1376	37	53
2.140-45	2.1430	69¼	20¾	2.1429	61	29	2.1403	55¼	34¾	2.1435	50½	39½				2.1412	43	46	2.1426	40	50			
2.145-50	2.1463	69½	20½	2.1479	61¼	28¾	2.1469	55½	34½				2.1461	46¾	43¼									
2.150-55	2.1533	70	20	2.1529	61½	28½	2.1531	55¾	34¼	2.1511	50¾	39¼	2.1549	47	43	2.1512	43¼	45¾	2.1537	40¼	49¾	2.1500	37¼	52¾
2.155-60	2.1567	70¼	19¾	2.1581	61¾	28¼	2.1595	56	34	2.1587	51	39												
2.160-65	2.1600	70½	19½	2.1632	62	28							2.1636	47¼	42¾	2.1611	43½	45½	2.1648	40½	49½	2.1622	37½	52½
2.165-70	2.1668	71	19	2.1682	62¼	27¾	2.1658	56¼	33¾	2.1664	51¼	38¾												
2.170-75	2.1730	71½	18½	2.1730	62½	27½	2.1721	56½	33½	2.1740	51½	38½	2.1724	47½	42½	2.1710	43¾	46¼				2.1745	37¾	52¼
2.175-80	2.1795	72	18	2.1780	62¾	27¼	2.1791	56¾	33¼										2.1758	40¾	49¼			
2.180-85	2.1825	72¼	17¾	2.1829	63	27	2.1849	57	33	2.1814	51¾	38¼	2.1808	47¾	42¼	2.1809	44	46						
2.185-90	2.1854	72½	17½	2.1879	63¼	26¾				2.1890	52	38	2.1896	48	42				2.1868	41	49	2.1861	38	52
2.190-95	2.1914	73	17	2.1925	63½	26½	2.1907	57¼	32¾							2.1907	44¼	45¾						
2.195-00	2.1971	73½	16½	2.1974	63¾	26¼	2.1970	57½	32½	2.1968	52¼	37¾	2.1980	48¼	41¾				2.1978	41¼	48¾	2.1989	38¼	51¾
2.200-05	2.2029	74	16	2.2020	64	26	2.2030	57¾	32¼	2.204	52½	37½				2.2005	44½	45½						
2.205-10	2.2084	74½	15½	2.2068	64¼	25¾	2.2089	58	32				2.2066	48½	41½				2.2087	41½	48½			
2.210-15	2.2136	75	15	2.2112	64½	25½				2.2112	52¾	37¼	2.2152	48¾	41¼	2.2103	44¾	45¼				2.2111	38½	51½
2.215-20	2.2187	75½	14½	2.2159	64¾	25¼	2.2150	58¼	31¾	2.2187	53	37							2.2195	41¾	48¼			
2.220-25	2.2237	76	14	2.2202	65	25	2.2209	58½	31½				2.2236	49	41	2.2200	45	45				2.2232	38¾	51¼
2.225-30	2.2283	76½	13½	2.2292	65½	24½	2.2269	58¾	31¼	2.2258	53¼	36¾												
2.230-35	2.2328	77	13	2.2339	65¾	24¼	2.2329	59	31	2.2331	53½	36½	2.2320	49¼	40¾	2.2297	45¼	44¾	2.2303	42	48			
2.235-40	2.2372	77½	12½	2.2381	66	24	2.2385	59¼	30¾							2.2393	45½	44½						
2.240-45	2.2415	78	12	2.2424	66¼	23¾	2.2443	59½	30½	2.2402	53¾	36¼	2.2404	49½	40½				2.2411	42¼	47¾	2.2351	39	51
2.245-50	2.2457	78½	11½	2.2479	66½	23½				2.2474	54	36	2.2488	49¾	40¼	2.2489	45¾	44¼				2.2473	30[illegible]	50[illegible]

Approximate Lead	Gear on Worm 28, 1st on Stud 64, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 86, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 56, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.250-55	2.2510	66¾	23¼	2.2500	59¾	30¼	2.2545	54¼	35¾							2.2520	42½	47½						
2.255-60	2.2551	67	23	2.2559	60	30				2.2571	50	40	2.2584	46	44				2.2594	39½	50½	2.2565	36¾	53¼
2.260-65	2.2634	67½	22½	2.2616	60¼	29¾	2.2615	54½	35½	2.2653	50¼	39¾				2.2625	42¾	47¼						
2.265-70	2.2679	67¾	22¼	2.2671	60½	29½	2.2686	54¾	35¼				2.2679	46¼	43¾							2.2697	37	53
2.270-75	2.2716	68	22	2.2729	61¾	28¼				2.2735	50½	39½				2.2732	43	47	2.2713	39¾	50¼			
2.275-80	2.2793	68½	21½	2.2781	61	29	2.2755	55	35				2.2773	46½	43½									
2.280-85	2.2834	68¾	21¼	2.2836	61¼	28¾	2.2825	55¼	34¾	2.2816	50¾	39¼				2.2839	43¼	46¾	2.2862	40	50	2.2827	37¼	52¾
2.285-90	2.2873	69	21	2.2890	61½	28½	2.2894	55½	34½	2.2896	51	39	2.2867	46¾	43¼									
2.290-95	2.2910	69¼	20¾	2.2948	61¾	28¼										2.2945	43½	46½						
2.295-00	2.2986	69¾	20¼				2.2961	55¾	34¼	2.2978	51¼	38¾	2.2961	47	43				2.2950	40¼	49¾	2.2959	37½	52½
2.300-05	2.3022	70	20	2.3001	62	28	2.3030	56	34							2.3049	43¾	46¼				2.3089	37¾	52¼
2.305-10	2.3095	70½	19½	2.3054	62¼	27¾	2.3097	56¼	33¾	2.3059	51½	38½	2.3055	47¼	42¾				2.3068	40½	49½			
2.310-15	2.3130	70¾	19¼	2.3104	62½	27½				2.3137	51¾	38¼												
2.315-20	2.3164	71	19	2.3158	62¾	27¼	2.3163	56½	33½				2.3148	47½	42½	2.3153	44	46	2.3185	40¾	49¼			
2.320-25	2.3200	71¼	18¾	2.3209	63	27	2.3239	56¾	33¼	2.3217	52	38	2.3239	47¾	42¼							2.3220	38	52
2.325-30	2.3267	71¾	18¼	2.3261	63¼	26¾				2.3299	52¼	37¾				2.3258	44¼	45¾						
2.330-35	2.3332	72¼	17¾	2.3311	63½	26½	2.3300	57	33				2.3331	48	42				2.3302	41	49	2.3348	38¼	51¾
2.335-40	2.3398	72¾	17¼	2.3364	63¾	26¼	2.3361	57¼	32¾	2.3376	52½	37½				2.3362	44½	45½						
2.340-45	2.3428	73	17	2.3411	64	26	2.3430	57½	32½				2.3423	48¼	41¾				2.3419	41¼	48¾			
2.345-50	2.3459	73¼	16¾	2.3461	64¼	25¾	2.3491	57¾	32¼	2.3454	52¾	37¼				2.3465	44¾	45¼				2.3476	38½	51½
2.350-55	2.3520	73¾	16¼	2.3511	64½	25½				2.3531	53	37	2.3514	48½	41½				2.3535	41½	48½			
2.355-60	2.3580	74½	15½	2.3560	64¾	25¼	2.3555	58	32							2.3570	45	45						
2.360-65	2.3638	74¾	15¼	2.3608	65	25	2.3620	58¼	31¾	2.3608	53¼	36¾	2.3604	48¾	41¼							2.3605	38¾	51¼
2.365-70	2.3665	75	15	2.3655	65¼	24¾	2.3685	58½	31½	2.3685	53½	36½	2.3694	49	41	2.3672	45¼	44¾	2.3651	41¾	48¼			
2.370-75	2.3720	75½	14½	2.3702	65½	24½	2.3748	58¾	31¼													2.3732	39	51
2.375-80	2.3798	76¼	13¾	2.3750	65¾	24¼				2.3761	53¾	36¼	2.3784	49¼	40¾	2.3773	45½	44½	2.3767	42	48			
2.380-85	2.3823	76½	13½	2.3842	66¼	23¾	2.3811	59	31	2.3837	54	36												
2.385-90	2.3871	77	13	2.3890	66½	23½	2.3872	59¼	30¾				2.3873	49½	40½	2.3875	45¾	44¼	2.3883	42¼	47¾	2.3861	39¼	50¾
2.390-95	2.3920	77½	12½	2.3929	66¾	23¼	2.3935	59½	30½	2.3912	54¼	35¾												
2.395-00	2.3965	78	12	2.3978	67	23	2.3996	59¾	30¼	2.3985	54½	35½	2.3962	49¾	40¼	2.3977	46	44	2.3997	42½	47½	2.3989	39½	50½

LEADS FROM 2.400 TO 2.550

Approximate Lead	Gear on Worm 40, 1st on Stud 86, 2nd on Stud 56, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 40, 1st on Stud 56, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.400-05	2.4021	67¼	22¾									
2.405-10	2.4065	67½	22½	2.4058	60	30	2.4060	54¾	35¼	2.4049	50	40
2.410-15	2.4111	67¾	22¼	2.4118	60¼	29¾	2.4135	55	35	2.4137	50¼	39¾
2.415-20	2.4150	68	22	2.4179	60½	29½						
2.420-25	2.4235	68½	21½	2.4238	60¾	29¼	2.4209	55¼	34¾	2.4224	50½	39½
2.425-30	2.4278	68¾	21¼	2.4297	61	29	2.4282	55½	34½			
2.430-35	2.4318	69	21							2.4311	50¾	39¼
2.435-40	2.4359	69¼	20¾	2.4354	61¼	28¾	2.4354	55¾	34¼	2.4398	51	39
2.440-45	2.4438	69¾	20¼	2.4410	61½	28½	2.4426	56	34			
2.445-50	2.4479	70	20	2.4471	61¾	28¼	2.4498	56¼	33¾	2.4484	51¼	38¾
2.450-55	2.4515	70¼	19¾	2.4529	62	28						
2.455-60	2.4554	70½	19½	2.4585	62¼	27¾	2.4569	56½	33½	2.4569	51½	38½
2.460-65	2.4630	71	19	2.4640	62½	27½	2.4640	56¾	33¼			
2.465-70	2.4666	71¼	18¾	2.4695	62¾	27¼				2.4654	51¾	38¼
2.470-75	2.4702	71½	18½				2.4710	57	33	2.4739	52	38
2.475-80	2.4774	72	18	2.4750	63	27	2.4780	57¼	32¾			
2.480-85	2.4841	72½	17½	2.4808	63¼	26¾	2.4849	57½	32½	2.4823	52¼	37¾
2.485-90	2.4878	72¾	17¼	2.4860	63½	26½						
2.490-95	2.4942	73¼	16¾	2.4915	63¾	26¼	2.4918	57¾	32¼	2.4907	52½	37½
2.495-00	2.4976	73½	16½	2.4969	64	26	2.4987	58	32	2.4990	52¾	37¼
2.500-05	2.5040	74	16	2.5020	64¼	25¾						
2.505-10	2.5071	74¼	15¾	2.5074	64½	25½	2.5055	58¼	31¾	2.5073	53	37
2.510-15	2.5102	74½	15½	2.5126	64¾	25¼	2.5122	58½	31½			
2.515-20	2.5191	75¼	14¾	2.5176	65	25	2.5189	58¾	31¼	2.5155	53¼	36¾
2.520-25	2.5220	75½	14½	2.5226	65¼	24¾				2.5237	53½	36½
2.525-30	2.5276	76	14	2.5279	65½	24½	2.5256	59	31			
2.530-35	2.5326	76½	13½	2.5329	65¾	24¼	2.5321	59¼	30¾	2.5318	53¾	36¼
2.535-40	2.5379	77	13	2.5380	66	24	2.5387	59½	30½	2.5399	54	36
2.540-45	2.5430	77½	12½	2.5426	66¼	23¾						
2.545-50	2.5478	78	12	2.5478	66½	23½	2.5452	59¾	30¼	2.5484	54¼	35¾

Approximate Lead	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.400-05										2.4044	36¾	53¼
2.405-10	2.4079	46¼	43¾									
2.410-15				2.4113	42¾	47¼	2.4116	39¾	50¼			
2.415-20	2.4179	46½	43½							2.4184	37	53
2.420-25				2.4224	43	47	2.4242	40	50			
2.425-30	2.4279	46¾	43¼									
2.430-35										2.4324	37¼	52¾
2.435-40	2.4378	47	43	2.4361	43¼	46¾	2.4368	40¼	49¾			
2.440-45				2.4446	43½	46½						
2.445-50	2.4477	47¼	42¾				2.4494	40½	49½	2.4464	37½	52½
2.450-55												
2.455-60	2.4576	47½	42½	2.4561	43¾	46¼						
2.460-65							2.4619	40¾	49¼	2.4603	37¾	52¼
2.465-70	2.4674	47¾	42¼	2.4672	44	46						
2.470-75							2.4743	41	49	2.4741	38	52
2.475-80	2.4771	48	42	2.4783	44¼	45¾						
2.480-85												
2.485-90	2.4868	48¼	41¾	2.4895	44½	45½	2.4867	41¼	48¾	2.4879	38¼	51¾
2.490-95												
2.495-00	2.4965	48½	41½				2.4990	41½	48½			
2.500-05				2.5005	44¾	45¼				2.5016	38½	51½
2.505-10	2.5061	48¾	41¼									
2.510-15				2.5116	45	45	2.5113	41¾	48¼			
2.515-20	2.5157	49	41							2.5153	38¾	51¼
2.520-25				2.5226	45¼	44¾	2.5236	42	48			
2.525-30	2.5252	49¼	40¾							2.5290	39	51
2.530-35	2.5347	49½	40½	2.5335	45½	44½						
2.535-40							2.5358	42¼	47¾			
2.540-45	2.5441	49¾	40¼	2.5442	45¾	44¼				2.5426	39¼	50¾
2.545-50							2.5480	42½	37½			

LEADS FROM 2.550 TO 2.700

Approximate Lead	Gear on Worm 40, 1st on Stud 56, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.550-55	2.5522	66¾	23¼	2.5517	60	30				2.5534	50	40
2.555-60	2.5569	67	23	2.5581	60¼	29¾	2.5560	54½	35½	2.5628	50¼	39¾
2.560-65	2.5617	67¼	22¾	2.5645	60½	29½	2.5639	54¾	35¼			
2.565-70	2.5663	67½	22½									
2.570-75	2.5709	67¾	22¼	2.5708	60¾	29¼	2.5717	55	35	2.5720	50½	39½
2.575-80	2.5755	68	22	2.5770	61	29	2.5796	55¼	34¾			
2.580-85	2.5845	68½	21½	2.5832	61¼	28¾				2.5812	50¾	39¼
2.585-90	2.5890	68¾	21¼	2.5894	61½	28½	2.5874	55½	34½			
2.590-95	2.5932	69	21							2.5904	51	39
2.595-00	2.5976	69¼	20¾	2.5955	61¾	28¼	2.5951	55¾	34¼	2.5995	51¼	38¾
2.600-05	2.6019	69½	20½	2.6016	62	28	2.6029	56	34			
2.605-10	2.6060	69¾	20¼	2.6076	62¼	27¾				2.6086	51½	38½
2.610-15	2.6143	70¼	19¾	2.6135	62½	27½	2.6104	56¼	33¾			
2.615-20	2.6185	70½	19½	2.6194	62¾	27¼	2.6180	56½	33½	2.6177	51¾	38¼
2.620-25	2.6227	70¾	19¼	2.6253	63	27						
2.625-30	2.6265	71	19				2.6256	56¾	33¼	2.6267	52	38
2.630-35	2.6342	71½	18½	2.6311	63¼	26¾	2.6330	57	33			
2.635-40	2.6381	71¾	18¼	2.6369	63½	26½				2.6356	52¼	37¾
2.640-45	2.6420	72	18	2.6426	63¾	26¼	2.6405	57¼	32¾	2.6445	52½	37½
2.645-50	2.6457	72¼	17¾	2.6482	64	26	2.6479	57½	32½			
2.650-55	2.6530	72¾	17¼	2.6538	64¼	25¾				2.6533	52¾	37¼
2.655-60	2.6565	73	17	2.6594	64½	25½	2.6552	57¾	32¼			
2.660-65	2.6636	73½	16½	2.6649	64¾	25¼	2.6625	58	32	2.6620	53	37
2.665-70	2.6670	73¾	16¼				2.6697	58¼	31¾			
2.670-75	2.6737	74¼	15¾	2.6704	65	25				2.6708	53¼	36¾
2.675-80	2.6770	74½	15½	2.6758	65¼	24¾	2.6769	58½	31½	2.6795	53½	36½
2.680-85	2.6831	75	15	2.6811	65½	24½	2.6840	58¾	31¼			
2.685-90	2.6892	75½	14½	2.6864	65¾	24¼				2.6880	53¾	36¼
2.690-95	2.6922	75¾	14¼	2.6917	66	24	2.6911	59	31			
2.695-00	2.6952	76	14	2.6969	66¼	23¾	2.6981	59¼	30¾	2.6968	54	36

Approximate Lead	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.550-55										2.5528	36¾	53¼
2.555-60	2.5557	46	44				2.5561	39½	50½			
2.560-65				2.5600	42¾	47¼						
2.565-70	2.5658	46¼	43¾				2.5696	39¾	50¼	2.5678	37	53
2.570-75				2.5721	43	47						
2.575-80	2.5762	46½	43½									
2.580-85							2.5831	40	50	2.5826	37¼	52¾
2.585-90	2.5871	46¾	43¼	2.5841	43¼	46¾						
2.590-95												
2.595-00	2.5976	47	43	2.5961	43½	46½	2.5965	40¼	49¾	2.5974	37½	52½
2.600-05												
2.605-10	2.6082	47¼	42¾	2.6080	43¾	46¼	2.5099	40½	49½	2.6122	37¾	52¼
2.610-15												
2.615-20	2.6188	47½	42½	2.6199	44	46						
2.620-25							2.6232	40¾	49¼			
2.625-30	2.6290	47¾	42¼							2.6268	38	52
2.630-35				2.6317	44¼	45¾						
2.635-40							2.6364	41	49			
2.640-45	2.6460	48	42	2.6434	44½	45½				2.6415	38¼	51¾
2.645-50							2.6496	41¼	48¾			
2.650-55	2.6500	48¼	41¾	2.6551	44¾	45¼						
2.655-60										2.6560	38½	51½
2.660-65	2.6601	48½	41½				2.6628	41½	48½			
2.665-70				2.6668	45	45						
2.670-75	2.6706	48¾	41¼							2.6705	38¾	51¼
2.675-80				2.6784	45¼	44¾	2.6759	41¾	48¼			
2.680-85	2.6801	49	41									
2.685-90							2.6890	42	48	2.6851	39	51
2.690-95				2.6900	45½	44½						
2.695-00	2.6989	49¼	40¾							2.6996	39¼	50¾

LEADS FROM 2.700 TO 2.850

Approximate Lead	Gear on Worm 24, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.700-05	2.7020	66½	23½
2.705-10	2.7071	66¾	23¼
2.710-15	2.7122	67	23
2.715-20	2.7172	67¼	22¾
2.720-25	2.7222	67½	22½
2.725-30	2.7271	67¾	22¼
2.730-35	2.7319	68	22
2.735-40	2.7367	68¼	21¾
2.740-45	2.7414	68½	21½
2.745-50	2.7461	68¾	21¼
2.750-55	2.7507	69	21
2.755-60	2.7598	69½	20½
2.760-65	2.7643	69¾	20¼
2.765-70	2.7687	70	20
2.770-75	2.7731	70¼	19¾
2.775-80	2.7774	70½	19½
2.780-85	2.7817	70¾	19¼
2.785-90	2.7859	71	19
2.790-95	2.7942	71½	18½
2.795-00	2.7982	71¾	18¼
2.800-05	2.8022	72	18
2.805-10	2.8062	72¼	17¾
2.810-15	2.8139	72¾	17¼
2.815-20	2.8177	73	17
2.820-25	2.8214	73¼	16¾
2.825-30	2.8251	73½	16¼
2.830-35	2.8323	74	16
2.835-40	2.8393	74½	15½
2.840-45	2.8427	74¾	15¼
2.845-50	2.8461	75	15

Approximate Lead	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.705-10	2.7051	59½	30½
2.710-15	2.7120	59¾	30¼
2.715-20	2.7189	60	30
2.725-30	2.7257	60¼	29¾
2.730-35	2.7325	60½	29½
2.735-40	2.7392	60¾	29¼
2.745-50	2.7459	61	29
2.750-55	2.7525	61¼	28¾
2.755-60	2.7591	61½	28½
2.765-70	2.7656	61¾	28¼
2.770-75	2.7721	62	28
2.775-80	2.7785	62¼	27¾
2.785-90	2.7848	62½	27½
2.790-95	2.7911	62¾	27¼
2.795-00	2.7974	63	27
2.800-05	2.8036	63¼	26¾
2.805-10	2.8097	63½	26½
2.815-20	2.8158	63¾	26¼
2.820-25	2.8218	64	26
2.825-30	2.8278	64¼	25¾
2.830-35	2.8337	64½	25½
2.835-40	2.8396		
2.845-50	2.8454	65	25

Approximate Lead	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.705-10	2.7051	54¼	35¾
2.710-15	2.7135	54½	35½
2.720-25	2.7220	54¾	35¼
2.730-35	2.7304	55	35
2.735-40	2.7387	55¼	34¾
2.745-50	2.7470	55½	34½
2.755-60	2.7552	55¾	34¼
2.760-65	2.7634	56	34
2.770-75	2.7715	56¼	33¾
2.775-80	2.7796	56½	33½
2.785-90	2.7876	56¾	33¼
2.795-00	2.7955	57	33
2.800-05	2.8034	57¼	32¾
2.810-15	2.8113	57½	32½
2.815-20	2.8191	57¾	32¼
2.825-30	2.8268	58	32
2.830-35	2.8345	58¼	31¾
2.840-45	2.8421	58½	31½
2.845-50	2.8497	58¾	31¼

Approximate Lead	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.700-05	2.7009	49½	40½
2.710-15	2.7110	49¾	40¼
2.720-25	2.7210	50	40
2.730-35	2.7310	50¼	39¾
2.740-45	2.7407	50½	39½
2.750-55	2.7505	50¾	39¼
2.760-65	2.7601	51	39
2.770-75	2.7700	51¼	38¾
2.775-80	2.7797	51½	38½
2.785-90	2.7891	51¾	38¼
2.795-00	2.7989	52	38
2.805-10	2.8087	52¼	37¾
2.815-20	2.8180	52½	37½
2.825-30	2.8275	52¾	37¼
2.835-40	2.8369	53	37
2.845-50	2.8461	53¼	36¾

Approximate Lead	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.700-05	2.7015	45¾	44¼
2.710-15	2.7129	46	44
2.720-25	2.7243	46¼	43¾
2.735-40	2.7357	46½	43½
2.745-50	2.7470	46¾	43¼
2.755-60	2.7582	47	43
2.765-70	2.7694	47¼	42¾
2.780-85	2.7806	47½	42½
2.790-95	2.7917	47¾	42¼
2.800-05	2.8027	48	42
2.810-15	2.8137	48¼	41¾
2.820-25	2.8246	48½	41½
2.835-40	2.8355	48¾	41¼
2.845-50	2.8463	49	41

Approximate Lead	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.700-05	2.7020	42¼	47¾
2.710-15	2.7149	42½	47½
2.725-30	2.7278	42¾	47¼
2.740-45	2.7407	43	47
2.755-60	2.7535	43¼	46¾
2.765-70	2.7662	43½	46½
2.775-80	2.7789	43¾	46¼
2.790-95	2.7915	44	46
2.800-05	2.8041	44¼	45¾
2.815-20	2.8166	44½	45½
2.825-30	2.8291	44¾	45¼
2.840-45	2.8416	45	45

Approximate Lead	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.710-15	2.7141	39½	50½
2.725-30	2.7282	39¾	50¼
2.740-45	2.7427	40	50
2.755-60	2.7567	40¼	49¾
2.770-75	2.7710	40½	49½
2.785-90	2.7851	40¾	49¼
2.795-00	2.7991	41	49
2.810-15	2.8132	41¼	48¾
2.825-30	2.8272	41½	48½
2.840-45	2.8411	41¾	48¼

Approximate Lead	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.710-15	2.7144	36¾	53¼
2.725-30	2.7303	37	53
2.745-50	2.7460	37¼	52¾
2.760-65	2.7618	37½	52½
2.775-80	2.7775	37¾	52¼
2.790-95	2.7931	38	52
2.800-05	2.8086	38¼	51¾
2.820-25	2.8240	38½	51½
2.835-40	2.8396	38¾	51¼

LEADS FROM 2.850 TO 3.000

Approximate Lead	Gear on Worm 24, 1st on Stud 86, 2nd on Stud 72, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.850-55	2.8512	65¼	24¾									
2.855-60	2.8569	65½	24½	2.8572	59	31	2.8553	53½	36½	2.8571	49¼	40¾
2.860-65	2.8625	65¾	24¼	2.8647	59¼	30¾	2.8645	53¾	36¼			
2.865-70	2.8682	66	24							2.8678	49½	40½
2.870-75	2.8736	66¼	23¾	2.8721	59½	30½	2.8737	54	36			
2.875-80	2.8792	66½	23½	2.8795	59¾	30¼				2.8785	49¾	40¼
2.880-85							2.8825	54¼	35¾			
2.885-90	2.8846	66¾	23¼	2.8868	60	30				2.8891	50	40
2.890-95	2.8900	67	23	2.8940	60¼	29¾	2.8916	54½	35½			
2.895-00	2.8953	67¼	22¾							2.8996	50¼	39¾
2.900-05	2.9006	67½	22½	2.9012	60½	29½	2.9005	54¾	35¼			
2.905-10	2.9058	67¾	22¼	2.9083	60¾	29¼	2.9095	55	35			
2.910-15	2.9109	68	22							2.9101	50½	39½
2.915-20	2.9160	68¼	21¾	2.9154	61	29	2.9185	55¼	34¾			
2.920-25	2.9211	68½	21½	2.9224	61¼	28¾				2.9206	50¾	39¼
2.925-30	2.9261	68¾	21¼	2.9294	61½	28½	2.9273	55½	34½			
2.930-35	2.9310	69	21							2.9310	51	39
2.935-40	2.9359	69¼	20¾	2.9363	61¾	28¼	2.9360	55¾	34¼			
2.940-45	2.9407	69½	20½	2.9432	62	28	2.9446	56	34	2.9413	51¼	38¾
2.945-50	2.9455	69¾	20¼									
2.950-55	2.9549	70¼	19¾	2.9500	62¼	27¾	2.9532	56¼	33¾	2.9516	51½	38½
2.955-60	2.9595	70½	19½	2.9567	62½	27½						
2.960-65	2.9640	70¾	19¼	2.9634	62¾	27¼	2.9618	56½	33½	2.9618	51¾	38¼
2.965-70	2.9685	71	19									
2.970-75	2.9729	71¼	18¾	2.9700	63	27	2.9704	56¾	33¼	2.9720	52	38
2.975-80	2.9773	71½	18½	2.9766	63¼	26¾	2.9789	57	33			
2.980-85	2.9816	71¾	18¼	2.9831	63½	26½				2.9821	52¼	37¾
2.985-90	2.9859	72	18	2.9898	63¾	26¼	2.9874	57¼	32¾			
2.990-95	2.9942	72½	17½							2.9921	52½	37½
2.995-00	2.9983	72¾	17¼	2.9960	64	26	2.9958	57½	32½			

Approximate Lead	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
2.850-55	2.8540	45¼	44¾									
2.855-60				2.8541	42	48	2.8552	39	51	2.8573	36	54
2.860-65												
2.865-70	2.8663	45½	44½	2.8689	42¼	47¾						
2.870-75							2.8705	39¼	50¾	2.8744	36¼	53¾
2.875-80	2.8785	45¾	44¼									
2.880-85				2.8825	42½	47½						
2.885-90							2.8858	39½	50½			
2.890-95	2.8907	46	44							2.8915	36½	53½
2.895-00				2.8962	42¾	47¼						
2.900-05	2.9029	46¼	43¾				2.9011	39¾	50¼			
2.905-10				2.9099	43	47				2.9085	36¾	53¼
2.910-15												
2.915-20	2.9150	46½	43½				2.9163	40	50			
2.920-25												
2.925-30	2.9270	46¾	43¼	2.9234	43¼	46¾				2.9255	37	53
2.930-35							2.9314	40¼	49¾			
2.935-40	2.9390	47	43	2.9370	43½	46½						
2.940-45										2.9424	37¼	52¾
2.945-50							2.9465	40½	49½			
2.950-55	2.9509	47¼	42¾	2.9503	43¾	46¼						
2.955-60										2.9592	37½	52½
2.960-65	2.9628	47½	42½	2.9638	44	46	2.9615	40¾	49¼			
2.965-70												
2.970-75	2.9746	47¾	42¼									
2.975-80				2.9771	44¼	45¾	2.9765	41	49	2.9761	37¾	52¼
2.980-85												
2.985-90	2.9864	48	42									
2.990-95				2.9905	44½	45½	2.9915	41¼	48¾	2.9929	38	52
2.995-00	2.9982	48¼	41¾									

LEADS FROM 3.000 TO 3.150

Approximate Lead	Gear on Worm 28, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
3.000-05	3.002	64¼	25¾	3.004	57¾	32¼	3.002	52¾	37¼			
3.005-10	3.009	64½	25½									
3.010-15				3.012	58	32	3.012	53	37	3.010	48½	41½
3.015-20	3.015	64¾	25¼									
3.020-25	3.021	65	25	3.020	58¼	31¾	3.021	53¼	36¾	3.022	48¾	41¼
3.025-30	3.027	65¼	24¾	3.028	58½	31½						
3.030-35	3.033	65½	24½				3.031	53½	36½	3.033	49	41
3.035-40	3.039	65¾	24¼	3.036	58¾	31¼						
3.040-45				3.044	59	31	3.041	53¾	36¼			
3.045-50	3.045	66	24							3.045	49¼	40¾
3.050-55	3.051	66¼	23¾	3.052	59¼	30¾	3.051	54	36			
3.055-60	3.057	66½	23½							3.056	49½	40½
3.060-65	3.062	66¾	23¼	3.060	59½	30½	3.060	54¼	35¾			
3.065-70	3.068	67	23	3.068	59¾	30¼				3.067	49¾	40¼
3.070-75	3.074	67¼	22¾				3.070	54½	35½			
3.075-80				3.076	60	30	3.079	54¾	35¼	3.079	50	40
3.080-85	3.080	67½	22½	3.084	60¼	29¾						
3.085-90	3.085	67¾	22¼				3.089	55	35			
3.090-95	3.090	68	22	3.091	60½	29½				3.090	50¼	39¾
3.095-00	3.096	68¼	21¾	3.099	60¾	29¼	3.098	55¼	34¾			
3.100-05	3.101	68½	21½							3.101	50½	39½
3.105-10	3.107	68¾	21¼	3.107	61	29	3.108	55½	34½			
3.110-15	3.112	69	21	3.114	61¼	28¾				3.112	50¾	39¼
3.115-20	3.117	69¼	20¾				3.117	55¾	34¼			
3.120-25	3.122	69½	20½	3.121	61½	28½				3.123	51	39
3.125-30	3.127	69¾	20¼	3.128	61¾	28¼	3.126	56	34			
3.130-35	3.132	70	20							3.134	51¼	38¾
3.135-40	3.137	70¼	19¾	3.136	62	28	3.135	56¼	33¾			
3.140-45	3.142	70½	19½	3.144	62¼	27¾	3.144	56½	33½			
3.145-50	3.147	70¾	19¼							3.145	51½	38½

Approximate Lead	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
3.000-05	3.004	44¾	45¼									
3.005-10				3.006	41½	48½	3.009	38¼	51¾			
3.010-15												
3.015-20	3.017	45	45							3.017	36	54
3.020-25				3.021	41¾	48¼						
3.025-30							3.026	38½	51½			
3.030-35	3.030	45¼	44¾									
3.035-40				3.036	42	48				3.035	36¼	53¾
3.040-45	3.043	45½	44½				3.042	38¾	51¼			
3.045-50												
3.050-55				3.050	42¼	47¾				3.053	36½	53½
3.055-60	3.056	45¾	44¼				3.059	39	51			
3.060-65												
3.065-70	3.069	46	44	3.065	42½	47½						
3.070-75										3.071	36¾	53¼
3.075-80							3.075	39¼	50¾			
3.080-85	3.082	46¼	43¾	3.080	42¾	47¼						
3.085-90										3.089	37	53
3.090-95				3.094	43	47	3.091	39½	50½			
3.095-00	3.095	46½	43½									
3.100-05												
3.105-10	3.108	46¾	43¼	3.109	43¼	46¾	3.108	39¾	50¼	3.107	37¼	52¾
3.110-15												
3.115-20												
3.120-25	3.120	47	43	3.123	43½	46½	3.124	40	50			
3.125-30										3.125	37½	52½
3.130-35	3.133	47¼	42¾									
3.135-40				3.137	43¾	46¼						
3.140-45							3.141	40¼	49¾	3.142	37¾	52¼
3.145-50	3.146	47½	42½									

Approximate Lead	Gear on Worm 48, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 44, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
3.150-55	3.150	62½	27½									
3.155-60	3.158	62¾	27¼	3.155	56¾	33¼	3.156	51¾	38¼	3.158	47¾	42¼
3.160-65				3.163	57	33						
3.165-70	3.165	63	27				3.167	52	38			
3.170-75	3.172	63¼	26¾	3.171	57¼	32¾				3.171	48	42
3.175-80	3.179	63½	26½				3.178	52¼	37¾			
3.180-85				3.180	57½	32½				3.183	48¼	41¾
3.185-90	3.186	63¾	26¼	3.189	57¾	32¼	3.189	52½	37½			
3.190-95	3.193	64	26									
3.195-00				3.198	58	32	3.199	52¾	37¼	3.195	48½	41½
3.200-05	3.200	64¼	25¾									
3.205-10	3.206	64½	25½	3.206	58¼	31¾				3.208	48¾	41¼
3.210-15	3.213	64¾	25¼				3.210	53	37			
3.215-20	3.219	65	25	3.215	58½	31½						
3.220-25				3.224	58¾	31¼	3.220	53¼	36¾	3.220	49	41
3.225-30	3.226	65¼	24¾									
3.230-35	3.232	65½	24½	3.232	59	31	3.231	53½	36½	3.232	49¼	40¾
3.235-40	3.239	65¾	24¼									
3.240-45				3.241	59¼	30¾	3.241	53¾	36¼	3.244	49½	40½
3.245-50	3.245	66	24	3.249	59½	30½						
3.250-55	3.251	66¼	23¾				3.251	54	36			
3.255-60	3.257	66½	23½	3.257	59¾	30¼				3.257	49¾	40¼
3.260-65	3.264	66¾	23¼				3.262	54¼	35¾			
3.265-70				3.266	60	30				3.269	50	40
3.270-75	3.270	67	23	3.274	60¼	29¾	3.272	54½	35½			
3.275-80	3.276	67¼	22¾									
3.280-85	3.282	67½	22½	3.282	60½	29½	3.282	54¾	35¼	3.280	50¼	39¾
3.285-90	3.288	67¾	22¼									
3.290-95	3.293	68	22	3.290	60¾	29¼	3.292	55	35	3.292	50½	39½
3.295-00	3.299	68¼	21¾	3.298	61	29						

Approximate Lead	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
3.150-55	3.151	44	46									
3.155-60				3.157	40½	49½						
3.160-65							3.160	38	52	3.159	35¼	54¾
3.165-70	3.166	44¼	45¾									
3.170-75				3.173	40¾	49¼						
3.175-80										3.178	35½	54½
3.180-85	3.180	44½	45½				3.178	38¼	51¾			
3.185-90												
3.190-95	3.194	44¾	45¼	3.189	41	49						
3.195-00							3.195	38½	51½	3.197	35¾	54¼
3.200-05												
3.205-10	3.208	45	45	3.205	41¼	48¾						
3.210-15							3.213	38¾	51¼	3.217	36	54
3.215-20												
3.220-25	3.222	45¼	44¾	3.221	41½	48½						
3.225-30												
3.230-35							3.230	39	51			
3.235-40	3.236	45½	44½	3.237	41¾	48¼				3.236	36¼	53¾
3.240-45												
3.245-50							3.248	39¼	50¾			
3.250-55	3.250	45¾	44¼	3.253	42	48						
3.255-60										3.255	36½	53½
3.260-65	3.264	46	44									
3.265-70				3.269	42¼	47¾	3.265	39½	50½			
3.270-75										3.274	36¾	53¼
3.275-80	3.277	46¼	43¾									
3.280-85				3.284	42½	47½	3.282	39¾	50¼			
3.285-90												
3.290-95	3.291	46½	43½							3.294	37	53
3.295-00				3.299	42¾	47¼	3.299	40	50			

LEADS FROM 3.300 TO 3.600

Approximate Lead	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.	Gear on Worm / 1st on Stud / 2nd on Stud / Gear on Screw	Angle to Set Spiral Head	Angle to Set Vertical Att.
	44 / 56 / 48 / 100	Degrees		72 / 100 / 48 / 86	Degrees		64 / 48 / 32 / 100	Degrees		56 / 48 / 28 / 72	Degrees		56 / 64 / 40 / 72	Degrees		56 / 48 / 44 / 100	Degrees		86 / 44 / 28 / 100	Degrees		100 / 48 / 24 / 86	Degrees	
3.300-10	3.306	61¼	28¾	3.302	55¼	34¾	3.304	50¾	39¼	3.304	46¾	43¼												
3.310-20	3.314	61½	28½	3.312	55½	34½	3.316	51	39	3.318	47	43	3.315	43	47	3.316	40¼	49¾	3.313	37¼	52¾	3.314	34¾	55¼
3.320-30	3.322	61¾	28¼	3.322	55¾	34¼	3.327	51¼	38¾															
3.330-40	3.330	62	28	3.332	56	34	3.339	51½	38½	3.331	47¼	42¾	3.331	43¼	46¾	3.333	40½	49½	3.332	37½	52½	3.335	35	55
3.340-50	3.345	62½	27½	3.341	56¼	33¾				3.345	47½	42½	3.346	43½	46½									
3.350-60	3.352	62¾	27¼	3.351	56½	33½	3.351	51¾	38¼	3.358	47¾	42¼				3.350	40¾	49¼	3.351	37¾	52¼	3.356	35¼	54¾
3.360-70	3.360	63	27	3.361	56¾	33¼	3.362	52	38				3.361	43¾	46¼	3.368	41	49	3.369	38	52			
3.370-80	3.375	63½	26½	3.371	57	33	3.374	52¼	37¾	3.372	48	42	3.376	44	46							3.376	35½	54½
3.380-90	3.382	63¾	26¼	3.380	57¼	32¾	3.385	52½	37½	3.385	48¼	41¾				3.384	41¼	48¾	3.388	38¼	51¾			
3.390-00	3.390	64	26	3.390	57½	32½	3.397	52¾	37¼	3.398	48½	41½	3.392	44¼	45¾							3.397	35¾	54¼
3.400-10	3.404	64½	25½	3.408	58	32	3.408	53	37				3.407	44½	45½	3.401	41½	48½	3.407	38½	51½			
3.410-20	3.418	65	25	3.417	58¼	31¾	3.419	53¼	36¾	3.411	48¾	41¼				3.418	41¾	48¼				3.418	36	54
3.420-30	3.424	65¼	24¾	3.427	58½	31½				3.424	49	41	3.422	44¾	45¼				3.425	38¾	51¼			
3.430-40	3.431	65½	24½	3.436	58¾	31¼	3.430	53½	36½	3.437	49¼	41¾	3.437	45	45	3.435	42	48				3.438	36¼	53¾
3.440-50	3.445	66	24	3.445	59	31	3.441	53¾	36¼										3.444	39	51			
3.450-60	3.458	66½	23½	3.454	59¼	30¾	3.452	54	36	3.450	49½	41½	3.452	45¼	44¾	3.451	42¼	47¾				3.458	36½	53½
3.460-70	3.469	66¾	23¼	3.462	59½	30½	3.463	54¼	35¾	3.463	49¾	41¼	3.467	45½	44½	3.468	42½	47½	3.463	39¼	50¾			
3.470-80	3.470	67	23	3.471	59¾	30¼	3.473	54½	35½	3.475	50	40										3.478	36¾	53¼
3.480-90	3.484	67½	22½	3.480	60	30	3.484	54¾	35¼	3.488	50¼	39¾	3.482	45¾	44¼	3.485	42¾	47¼	3.481	39½	50½			
3.490-00	3.496	68	22	3.498	60½	29½	3.495	55	35				3.496	46	44				3.499	39¾	50¼	3.499	37	53
3.500-10	3.508	68½	21½	3.507	60¾	29¼	3.506	55¼	34¾	3.500	50½	39½				3.500	43	47						
3.510-20	3.514	68¾	21¼	3.515	61	29	3.516	55½	34½	3.513	50¾	39¼	3.511	46¼	43¾	3.517	43¼	46¾	3.518	40	50	3.519	37¼	52¾
3.520-30	3.520	69	21	3.523	61¼	28¾	3.527	55¾	34¼	3.525	51	39	3.526	46½	43½									
3.530-40	3.532	69½	20½	3.531	61½	28½	3.537	56	34	3.538	51¼	38¾				3.533	43½	46½	3.536	40¼	49¾	3.539	37½	52½
3.540-50	3.543	70	20	3.549	62	28	3.547	56¼	33¾				3.540	46¾	43¼	3.549	43¾	46¼						
3.550-60	3.544	70½	19½	3.557	62¼	27¾	3.558	56½	33½	3.550	51½	38½	3.555	47	43				3.554	40½	49½	3.559	37¾	52¼
3.560-70	3.565	71	19	3.565	62½	27½	3.568	56¾	33¼	3.562	51¾	38¼	3.569	47¼	42¾	3.565	44	46						
3.570-80	3.576	71½	18½	3.573	62¾	27¼	3.579	57	33	3.575	52	38							3.572	40¾	49¼	3.574	38	52
3.580-90	3.586	72	18	3.581	63	27	3.588	57¼	32¾	3.588	52¼	37¾	3.584	47½	42½	3.582	44¼	45¾	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3.590-00	3.591	72¼	17¾	3.596	63¼	26¾	3.599	57½	32½				3.597	47¾	42¼	3.597	44½	45½						

LEADS FROM 3.600 TO 3.900

Approximate Lead	Gear on Worm 72, 1st on Stud 100, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
3.600-10	3.605	63¾	26¼	3.608	57¾	32¼	3.600	52½	37½							3.608	41¼	48¾				3.606	35¾	54¼
3.610-20	3.612	64	26	3.618	58	32	3.612	52¾	37¼	3.613	48	42	3.614	44¾	45¼				3.619	38½	51½			
3.620-30	3.620	64¼	25¾	3.628	58¼	31¾	3.623	53	37	3.627	48¼	41¾				3.626	41½	48½				3.627	36	54
3.630-40	3.635	64¾	25¼	3.638	58½	31½	3.635	53¼	36¾				3.630	45	45				3.639	38¾	51¼			
3.640-50	3.642	65	25	3.647	58¾	31¼	3.647	53½	36½	3.641	48½	41½	3.645	45¼	44¾	3.644	41¾	48¼				3.649	36¼	53¾
3.650-60	3.657	65½	24½	3.657	59	31	3.659	53¾	36¼	3.655	48¾	41¼							3.659	39	51			
3.660-70	3.664	65¾	24¼	3.667	59¼	30¾				3.669	49	41	3.661	45½	44½	3.662	42	48						
3.670-80	3.672	66	24	3.676	59½	30½	3.670	54	36				3.677	45¾	44¼				3.678	39¼	50¾	3.671	36½	53½
3.680-90	3.686	66½	23½	3.686	59¾	30¼	3.682	54¼	35¾	3.682	49¼	40¾				3.680	42¼	47¾						
3.690-00	3.699	67	23	3.695	60	30	3.693	54½	35½	3.696	49½	40½	3.692	46	44	3.697	42½	47½	3.698	39½	50½	3.692	36¾	53¼
3.700-10	3.706	67¼	22¾	3.704	60¼	29¾	3.705	54¾	35¼	3.710	49¾	40¼	3.707	46¼	43¾									
3.710-20	3.712	67½	22½	3.714	60½	29½	3.716	55	35							3.715	42¾	47¼	3.717	39¾	50¼	3.714	37	53
3.720-30	3.726	68	22	3.723	60¾	29¼	3.728	55¼	34¾	3.724	50	40	3.723	46½	43½									
3.730-40	3.739	68½	21½	3.732	61	29	3.739	55½	34½	3.737	50¼	39¾	3.738	46¾	43¼	3.732	43	47	3.737	40	50	3.735	37¼	52¾
3.740-50	3.745	68¾	21¼	3.749	61½	28½																		
3.750-60	3.752	69	21	3.759	61¾	28¼	3.750	55¾	34¼	3.751	50½	39½	3.754	47	43	3.750	43¼	46¾	3.756	40¼	49¾	3.756	37½	52½
3.760-70	3.764	69½	20½	3.768	62	28	3.761	56	34	3.764	50¾	39¼	3.769	47¼	42¾	3.769	43½	46½						
3.770-80	3.777	70	20	3.776	62¼	27¾	3.772	56¼	33¾	3.778	51	39							3.776	40½	49½	3.778	37¾	52¼
3.780-90	3.788	70½	19½	3.785	62½	27½	3.783	56½	33½				3.784	47½	42½	3.784	43¾	46¼						
3.790-00	3.794	70¾	19¼	3.793	62¾	27¼	3.794	56¾	33¼	3.791	51¼	38¾	3.799	47¾	42¼				3.795	40¾	49¼	3.799	38	52
3.800-10	3.800	71	19	3.802	63	27	3.805	57	33	3.804	51½	38½				3.801	44	46						
3.810-20	3.811	71½	18½	3.819	63½	26½	3.816	57¼	32¾	3.817	51¾	38¼	3.815	48	42	3.819	44¼	45¾	3.814	41	49			
3.820-30	3.822	72	18	3.827	63¾	26¼	3.827	57½	32½													3.820	38¼	51¾
3.830-40	3.833	72½	17½	3.835	64	26	3.837	57¾	32¼	3.830	52	38	3.830	48¼	41¾	3.836	44½	45½	3.833	41¼	48¾			
3.840-50	3.843	73	17	3.843	64¼	25¾	3.847	58	32	3.843	52¼	37¾	3.845	48½	41½							3.841	38½	51½
3.850-60	3.854	73½	16½	3.851	64½	25½	3.858	58¼	31¾	3.856	52½	37½	3.859	48¾	41¼	3.853	44¾	45¼	3.852	41½	48½			
3.860-70	3.863	74	16	3.867	65	25	3.868	58½	31½	3.869	52¾	37¼										3.862	38¾	51¼
3.870-80	3.873	74½	15½	3.875	65¼	24¾	3.878	58¾	31¼				3.874	49	41	3.870	45	45	3.871	41¾	48¼			
3.880-90	3.882	75	15	3.883	65½	24½	3.889	59	31	3.882	53	37	3.888	49¼	40¾	3.887	45¼	44¾				3.883	39	51
3.890-00	3.891	75½	14½	3.898	66	24	3.899	59¼	30¾	3.895	53¼	36¾							3.890	42	48			

LEADS FROM 3.900 TO 4.200

Approximate Lead	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 32, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
3.900-10	3.905	66¼	23¾	3.909	59½	30½	3.907	53½	36½	3.903	49½	40½	3.904	45½	44½				3.904	39¼	50¾			
3.910-20	3.913	66½	23½	3.919	59¾	30¼				3.917	49¾	40¼				3.910	42¼	47¾				3.913	36½	53½
3.920-30	3.927	67	23	3.929	60	30	3.920	53¾	36¼				3.920	45¾	44¼	3.928	42½	47½	3.925	39½	50½			
3.930-40	3.935	67¼	22¾	3.939	60¼	29¾	3.933	54	36	3.932	50	40	3.937	46	44							3.935	36¾	53¼
3.940-50	3.942	67½	22½	3.949	60½	29½	3.945	54¼	35¾	3.946	50¼	39¾				3.946	42¾	47¼	3.946	39¾	50¼			
3.950-60	3.956	68	22	3.958	60¾	29¼	3.956	54½	35½				3.953	46¼	43¾							3.959	37	53
3.960-70	3.963	68¼	21¾	3.968	61	29	3.969	54¾	35¼	3.961	50½	39½				3.965	43	47	3.966	40	50			
3.970-80	3.970	68½	21½	3.977	61¼	28¾				3.975	50¾	39¼	3.970	46½	43½									
3.980-90	3.983	69	21	3.987	61½	28½	3.982	55	35	3.989	51	39	3.986	46¾	43¼	3.984	43¼	46¾	3.987	40¼	49¾	3.981	37¼	52¾
3.990-00	3.996	69½	20½	3.997	61¾	28¼	3.994	55¼	34¾															
4.000-10	4.003	69¾	20¼	4.006	62	28	4.006	55½	34½	4.003	51¼	38¾	4.003	47	43	4.002	43½	46½	4.008	40½	49½	4.004	37½	52½
4.010-20	4.010	70	20	4.015	62¼	27¾	4.018	55¾	34¼	4.017	51½	38½	4.019	47¼	42¾									
4.020-30	4.022	70½	19½	4.024	62½	27½										4.020	43¾	46¼	4.028	40¾	49¼	4.027	37¾	52¼
4.030-40	4.034	71	19	4.033	62¾	27¼	4.030	56	34	4.031	51¾	38¼	4.035	47½	42½	4.038	44	46						
4.040-50	4.046	71½	18½	4.042	63	27	4.041	56¼	33¾	4.045	52	38							4.048	41	49	4.050	38	52
4.050-60	4.058	72	18	4.052	63¼	26¾	4.054	56½	33½	4.059	52¼	37¾	4.051	47¾	42¼	4.057	44¼	45¾						
4.060-70	4.069	72½	17½	4.060	63½	26½	4.065	56¾	33¼				4.067	48	42				4.069	41¼	48¾			
4.070-80	4.075	72¾	17¼	4.078	64	26	4.077	57	33	4.072	52½	37½				4.075	44½	45½				4.072	38¼	51¾
4.080-90	4.080	73	17	4.086	64¼	25¾	4.088	57¼	32¾	4.086	52¾	37¼	4.084	48¼	41¾				4.089	41½	48½			
4.090-00	4.091	73½	16½	4.095	64½	25½							4.099	48½	41½	4.093	44¾	45¼				4.095	38½	51½
4.100-10	4.101	74	16	4.104	64¾	25¼	4.100	57½	32½	4.100	53	37							4.109	41¾	48¼			
4.110-20	4.112	74½	15½	4.112	65	25	4.111	57¾	32¼	4.113	53¼	36¾	4.115	48¾	41¼	4.111	45	45				4.117	38¾	51¼
4.120-30	4.121	75	15	4.128	65½	24½	4.122	58	32	4.126	53½	36½				4.129	45¼	44¾	4.129	42	48			
4.130-40	4.131	75½	14½	4.137	65¾	24¼	4.133	58¼	31¾				4.130	49	41									
4.140-50	4.149	76½	13½	4.145	66	24	4.144	58½	31½	4.140	53¾	36¼	4.146	49¼	40¾	4.147	45½	44½	4.149	42¼	47¾	4.140	39	51
4.150-60	4.157	77	13	4.153	66¼	23¾	4.156	58¾	31¼	4.153	54	36												
4.160-70	4.166	77½	12½	4.161	66½	23½	4.167	59	31	4.165	54¼	35¾	4.161	49½	40½	4.164	45¾	44¼	4.169	42½	47½	4.162	39¼	50¾
4.170-80	4.174	78	12	4.176	67	23	4.177	59¼	30¾	4.178	54½	35½	4.177	49¾	40¼									
4.180-90	4.181	78½	11½	4.184	67¼	22¾	4.189	59½	30½							4.182	46	44	4.189	42¾	47¼	4.184	39½	50½
4.190-00	4.195	79½	10½	4.199	67¾	22¼	4.199	59¾	30¼	4.192	54¾	35¼	4.192	50	40	4.192	46¼	43¾						

Approximate Lead	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 28, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
4.200-10	4.206	68	22	4.209	60	30	4.204	55	35	4.208	50¼	39¾				4.208	43	47	4.206	39¾				
4.210-20	4.214	68¼	21¾				4.217	55¼	34¾				4.217	46½	43½							4.213	37	53
4.220-30	4.221	68½	21½	4.220	60¼	29¾				4.223	50½	39½				4.229	43¼	46¾	4.228	40	50			
4.230-40	4.235	69	21	4.231	60½	29½	4.230	55½	34½	4.238	50¾	39¼	4.234	46¾	43¼							4.237	37¼	52¾
4.240-50	4.249	69½	20½	4.242	60¾	29¼	4.243	55¾	34¼							4.247	43½	46½						
4.250-60	4.256	69¾	20¼	4.252	61	29	4.256	56	34	4.253	51	39	4.252	47	43				4.250	40¼	49¾			
4.260-70	4.267	70¼	19¾	4.262	61¼	28¾	4.268	56¼	33¾	4.268	51¼	38¾	4.269	47¼	42¾	4.267	43¾	46¼				4.261	37½	52½
4.270-80	4.277	70½	19½	4.272	61½	28½													4.272	40½	49½			
4.280-90	4.283	70¾	19¼	4.282	61¾	28¼	4.281	56½	33½	4.283	51½	38½	4.287	47½	42½	4.286	44	46				4.286	37¾	52¼
4.290-00	4.290	71	19	4.292	62	28	4.293	56¾	33¼	4.298	51¾	38¼							4.294	40¾	49¼			
4.300-10	4.309	71¾	18¼	4.302	62¼	27¾	4.305	57	33				4.304	47¾	42¼	4.306	44¼	45¾						
4.310-20	4.315	72	18	4.312	62½	27½	4.317	57¼	32¾	4.313	52	38							4.316	41	49	4.310	38	52
4.320-30	4.327	72½	17½	4.321	62¾	27¼	4.329	57½	32½	4.327	52¼	37¾	4.321	48	42	4.325	44½	45½						
4.330-40	4.333	72¾	17¼	4.331	63	27							4.338	48¼	41¾				4.337	41¼	48¾	4.334	38¼	51¾
4.340-50	4.344	73¼	16¾	4.341	63¼	26¾	4.341	57¾	32¼	4.342	52½	37½				4.344	44¾	45¼						
4.350-60	4.350	73½	16½	4.350	63½	26½	4.353	58	32	4.357	52¾	37¼	4.355	48½	41½				4.358	41½	48½	4.357	38½	51½
4.360-70	4.361	74	16	4.369	64	26	4.365	58¼	31¾							4.364	45	45						
4.370-80	4.377	74¾	15¼	4.378	64¼	25¾	4.376	58½	31½	4.372	53	37	4.371	48¾	41¼									
4.380-90	4.381	75	15	4.387	64½	25½	4.388	58¾	31¼	4.385	53¼	36¾	4.388	49	41	4.382	45¼	44¾	4.380	41¾	48¼	4.381	38¾	51¼
4.390-00	4.392	75½	14½	4.396	64¾	25¼				4.399	53½	36½												
4.400-10	4.407	76¼	13¾	4.405	65	25	4.400	59	31				4.404	49¼	40¾	4.401	45½	44½	4.402	42	48	4.405	39	51
4.410-20	4.416	76¾	13¼	4.414	65¼	24¾	4.411	59¼	30¾	4.413	53¾	36¼												
4.420-30	4.424	77¼	12¾	4.423	65½	24½	4.422	59½	30½	4.428	54	36	4.421	49½	40½	4.420	45¾	44¼	4.423	42¼	47¾	4.429	39¼	50¾
4.430-40	4.438	78	12	4.432	65¾	24¼	4.434	59¾	30¼				4.437	49¾	40¼	4.439	46	44						
4.440-50	4.442	78½	11½	4.440	66	24	4.445	60	30	4.442	54¼	35¾							4.444	42½	47½			
4.450-60	4.453	79	11	4.457	66½	23½	4.456	60¼	29¾	4.455	54½	35½	4.454	50	40	4.457	46¼	43¾				4.453	39½	50½
4.460-70	4.461	79½	10½	4.466	66¾	23¼	4.468	60½	29½	4.469	54¾	35¼							4.465	42¾	47¼			
4.470-80				4.474	67	23	4.478	60¾	29¼				4.470	50¼	39¾	4.476	46½	43½				4.476	39¾	50¼
4.480-90				4.483	67¼	22¾	4.489	61	29	4.483	55	35	4.486	50½	39½				4.486	43	47			
4.490-00				4.491	67½	22½				4.497	55¼	34¾				4.495	46¾	43¼				4.499	40	50

LEADS FROM 4.500 TO 4.800

Approximate Lead	Gear on Worm 56, 1st on Stud 64, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
4.500-10	4.507	68	22	4.500	61¼	28¾				4.502	50¾	39¼
4.510-20	4.515	68¼	21¾	4.511	61½	28½	4.510	55½	34½	4.518	51	39
4.520-30	4.523	68½	21½	4.521	61¾	28¼	4.524	55¾	34¼			
4.530-40	4.538	69	21	4.532	62	28	4.537	56	34	4.534	51¼	38¾
4.540-50	4.545	69¼	20¾	4.543	62¼	27¾						
4.550-60	4.553	69½	20½	4.553	62½	27½	4.550	56¼	33¾	4.550	51½	38½
4.560-70	4.561	69¾	20¼	4.565	62¾	27¼	4.564	56½	33½	4.566	51¾	38¼
4.570-80	4.575	70¼	19¾	4.573	63	27	4.577	56¾	33¼			
4.580-90	4.582	70½	19½	4.584	63¼	26¾				4.581	52	38
4.590-00	4.596	71	19	4.593	63½	26½	4.590	57	33	4.597	52¼	37¾
4.600-10	4.610	71¼	18¾	4.603	63¾	26¼	4.603	57¼	32¾			
4.610-20	4.616	71¾	18¼	4.613	64	26	4.616	57½	32½	4.612	52½	37½
4.620-30	4.629	72¼	17¾	4.623	64¼	25¾	4.629	57¾	32¼	4.628	52¾	37¼
4.630-40	4.636	72½	17½	4.633	64½	25½						
4.640-50	4.648	73	17	4.642	64¾	25¼	4.641	58	32	4.643	53	37
4.650-60	4.654	73¼	16¾	4.652	65	25	4.654	58¼	31¾	4.658	53¼	36¾
4.660-70	4.660	73½	16½	4.661	65¼	24¾	4.666	58½	31½			
4.670-80	4.672	74	16	4.671	65½	24½	4.678	58¾	31¼	4.673	53½	36½
4.680-90	4.689	74¾	15¼	4.680	65¾	24¼				4.689	53¾	36¼
4.690-00	4.695	75	15	4.698	66¼	23¾	4.691	59	31			
4.700-10	4.701	75¼	15¾	4.707	66½	23½	4.703	59¼	30¾	4.704	54	36
4.710-20	4.711	75¾	14¼	4.716	66¾	23¼	4.715	59½	30½	4.718	54¼	35¾
4.720-30	4.720	76¼	13¾	4.725	67	23	4.727	59¾	30¼			
4.730-40	4.736	77	13	4.733	67¼	22¾				4.733	54½	35½
4.740-50	4.746	77½	12½	4.742	67½	22½	4.740	60	30	4.748	54¾	35¼
4.750-60	4.750	77¾	12¼	4.759	68	22	4.752	60¼	29¾			
4.760-70	4.763	78½	11½	4.767	68¼	21¾	4.764	60½	29½	4.762	55	35
4.770-80	4.772	79	11	4.774	68½	21½	4.775	60¾	29¼	4.777	55¼	34¾
4.780-90	4.783	79¾	10¼	4.784	68¾	21¼	4.787	61	29			
4.790-00				4.793	69	21	4.798	61¼	28¾	4.792	55½	34½

Approximate Lead	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
4.500-10				4.507	43¼	46¾				4.504	37¼	52¾
4.510-20	4.513	47	43									
4.520-30				4.528	43½	46½	4.523	40¼	49¾			
4.530-40	4.531	47¼	42¾							4.530	37½	52½
4.540-50				4.549	43¾	46¼	4.546	40½	49½			
4.550-60	4.550	47½	42½							4.556	37¾	52¼
4.560-70	4.568	47¾	42¼	4.569	44	46	4.569	40¾	49¼			
4.570-80												
4.580-90	4.586	48	42							4.582	38	52
4.590-00				4.590	44¼	45¾	4.592	41	49			
4.600-10	4.604	48¼	41¾							4.607	38¼	51¾
4.610-20				4.610	44½	45½	4.615	41¼	48¾			
4.620-30	4.622	48½	41½									
4.630-40	4.639	48¾	41¼	4.631	44¾	45¼	4.638	41½	48½	4.633	38½	51½
4.640-50												
4.650-60	4.657	49	41	4.651	45	45				4.658	38¾	51¼
4.660-70							4.661	41¾	48¼			
4.670-80	4.674	49¼	40¾	4.672	45¼	44¾						
4.680-90							4.684	42	48	4.683	39	51
4.690-00	4.692	49½	40½	4.692	45½	44½						
4.700-10	4.709	49¾	40¼				4.707	42¼	47¾	4.708	39¼	50¾
4.710-20				4.712	45¾	44¼						
4.720-30	4.727	50	40				4.729	42½	47½			
4.730-40				4.731	46	44				4.734	39½	50½
4.740-50	4.744	50¼	39¾									
4.750-60				4.751	46¼	43¾	4.752	42¾	47¼	4.758	39¾	50¼
4.760-70	4.762	50½	39½									
4.770-80	4.779	50¾	39¼	4.771	46½	43½	4.774	43	47			
4.780-90												
4.790-00	4.796	51	39	4.791	46¾	43¼	4.796	43¼	46¾			

Approximate Lead	Gear on Worm 56, 1st on Stud 48, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angleto Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
4.800-10	4.808	69½	20½				4.806	55¾	34¼										4.808	40¼	49¾			
4.810-20	4.816	69¾	20¼	4.810	61½	28½				4.813	51¼	38¾	4.812	47	43	4.818	43½	46½						
4.820-30	4.824	70	20	4.821	61¾	28¼	4.820	56	34	4.829	51½	38½										4.821	37½	52½
4.830-40	4.839	70½	19½	4.833	62	28	4.834	56¼	33¾				4.830	47¼	42¾				4.833	40½	49½			
4.840-50	4.846	70¾	19¼	4.843	62¼	27¾	4.848	56½	33½	4.846	51¾	38¼				4.841	43¾	46¼				4.849	37¾	52¼
4.850-60	4.853	71	19	4.854	62½	27½							4.850	47½	42½				4.858	40¾	49¼			
4.860-70	4.865	71¼	18¾	4.865	62¾	27¼	4.862	56¾	33¼	4.863	52	38	4.869	47¾	42¼	4.862	44	46						
4.870-80	4.875	71¾	18¼	4.876	63	27	4.876	57	33	4.879	52¼	37¾										4.876	38	52
4.880-90	4.881	72	18	4.887	63¼	26¾							4.888	48	42	4.885	44¼	45¾	4.882	41	49			
4.890-00	4.895	72½	17½	4.898	63½	26½	4.890	57¼	32¾	4.896	52½	37½												
4.900-10	4.902	72¾	17¼	4.908	63¾	26¼	4.903	57½	32½				4.908	48¼	41¾	4.906	44½	45½	4.907	41¼	48¾	4.903	38¼	51¾
4.910-20	4.915	73¼	17¾	4.919	64	26	4.917	57¾	32¼	4.912	52¾	37¼												
4.920-30	4.921	73½	17½	4.929	64¼	25¾				4.928	53	37	4.927	48½	41½	4.928	44¾	45¼						
4.930-40	4.934	74	16				4.930	58	32										4.931	41½	48½	4.930	38½	51½
4.940-50	4.946	74½	15½	4.940	64½	25½	4.944	58¼	31¾	4.944	53¼	36¾	4.945	48¾	41¼									
4.950-60	4.952	74¾	15¼	4.950	64¾	25¼	4.957	58½	31½							4.950	45	45	4.955	41¾	48¼	4.957	38¾	51¼
4.960-70	4.964	75¼	14¾	4.960	65	25				4.961	53½	36½	4.964	49	41									
4.970-80	4.975	75¾	14¼	4.970	65¼	24¾	4.970	58¾	31¼	4.976	53¾	36¼				4.971	45¼	44¾						
4.980-90	4.986	76¼	13¾	4.980	65½	24½	4.984	59	31				4.983	49¼	40¾				4.980	42	48	4.984	39	51
4.990-00	4.996	76½	13½	4.990	65¾	24¼	4.996	59¼	30¾	4.992	54	36				4.993	45½	44½						
5.000-10	5.001	77	13	5.000	66	24	5.009	59½	30½	5.008	54¼	35¾	5.002	49½	40½				5.004	42¼	47¾			
5.010-20	5.016	77¾	12¼	5.019	66½	23½										5.014	45¾	44¼				5.011	39¼	50¾
5.020-30	5.025	78¼	11¾	5.028	66¾	23¼	5.022	59¾	30¼	5.024	54½	35½	5.020	49¾	40¼				5.028	42½	47½			
5.030-40	5.030	78½	11½	5.038	67	23	5.035	60	30	5.039	54¾	35¼	5.039	50	40	5.035	46	44				5.038	39½	50½
5.040-50	5.043	79¼	10¾	5.047	67¼	22¾	5.048	60¼	29¾															
5.050-60	5.051	79¾	10¼	5.056	67½	22½				5.055	55	35	5.058	50¼	39¾	5.056	46¼	43¾	5.052	42¾	47¼			
5.060-70				5.065	67¾	22¼	5.061	60½	29½													5.064	39¾	50¼
5.070-80				5.072	68	22	5.073	60¾	29¼	5.070	55¼	34¾	5.076	50½	39½	5.077	46½	43½	5.075	43	47			
5.080-90				5.083	68¼	21¾	5.085	61	29	5.086	55½	34½												
5.090-00				5.092	68½	21½	5.097	61¼	28¾				5.094	50¾	39¼	5.098	46¾	43¼	5.099	43¼	46¾	5.091	40	50

LEADS FROM 5.100 TO 5.400

Approximate Lead	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 28, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.100-10	5.109	69	21			
5.110-20	5.118	69¼	20¾	5.110	61½	28½
5.120-30	5.126	69½	20½	5.121	61¾	28¼
5.130-40	5.135	69¾	20¼	5.133	62	28
5.140-50	5.143	70	20	5.145	62¼	27¾
5.150-60	5.151	70¼	19¾	5.157	62½	27½
5.160-70	5.167	70¾	19¼	5.169	62¾	27¼
5.170-80	5.175	71	19			
5.180-90	5.182	71¼	18¾	5.180	63	27
5.190-00	5.190	71½	18½	5.192	63¼	26¾
5.200-10	5.204	72	18	5.203	63½	26½
5.210-20	5.212	72¼	17¾	5.214	63¾	26¼
5.220-30	5.226	72¾	17¼	5.225	64	26
5.230-40	5.233	73	17	5.236	64¼	25¾
5.240-50	5.240	73¼	16¾	5.247	64½	25½
5.250-60	5.254	73¾	16¼	5.258	64¾	25¼
5.260-70	5.261	74	16	5.269	65	25
5.270-80	5.274	74½	15½			
5.280-90	5.286	75	15	5.280	65¼	24¾
5.290-00	5.298	75½	14½	5.290	65½	24½
5.300-10	5.304	75¾	14¼	5.300	65¾	24¼
5.310-20	5.310	76	14	5.311	66	24
5.320-30	5.327	76¾	13¼	5.321	66¼	23¾
5.330-40	5.332	77	13	5.332	66½	23½
5.340-50	5.348	77¾	12¼	5.342	66¾	23¼
5.350-60	5.353	78	12	5.352	67	23
5.360-70	5.368	78¾	11¼	5.362	67¼	22¾
5.370-80	5.377	79¼	10¾	5.372	67½	22½
5.380-90	5.385	79¾	10¼	5.381	67¾	22¼
5.390-00	5.390	80	10	5.391	68	22

Approximate Lead	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.100-10	5.101	55¾	34¼			
5.110-20	5.117	56	34	5.112	51	39
5.120-30						
5.130-40	5.131	56¼	33¾	5.130	51¼	38¾
5.140-50	5.146	56½	33½	5.148	51½	38½
5.150-60						
5.160-70	5.161	56¾	33¼	5.166	51¾	38¼
5.170-80	5.176	57	33			
5.180-90				5.183	52	38
5.190-00	5.191	57¼	32¾			
5.200-10	5.204	57½	32½	5.205	52¼	37¾
5.210-20	5.219	57¾	32¼	5.218	52½	37½
5.220-30						
5.230-40	5.233	58	32	5.236	52¾	37¼
5.240-50	5.247	58¼	31¾			
5.250-60				5.253	53	37
5.260-70	5.261	58½	31½			
5.270-80	5.275	58¾	31¼	5.270	53¼	36¾
5.280-90				5.288	53½	36½
5.290-00	5.290	59	31			
5.300-10	5.303	59¼	30¾	5.305	53¾	36¼
5.310-20	5.316	59½	30½			
5.320-30				5.322	54	36
5.330-40	5.330	59¾	30¼	5.338	54¼	35¾
5.340-50	5.344	60	30			
5.350-60	5.358	60¼	29¾	5.355	54½	35½
5.360-70						
5.370-80	5.371	60½	29½	5.372	54¾	35¼
5.380-90	5.384	60¾	29¼	5.388	55	35
5.390-00	5.397	61	29			

Approximate Lead	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.100-10						
5.110-20						
5.120-30	5.120	47	43	5.122	43½	46½
5.130-40						
5.140-50	5.140	47¼	42¾	5.146	43¾	46¼
5.150-60						
5.160-70	5.161	47½	42½	5.169	44	46
5.170-80						
5.180-90	5.182	47¾	42¼			
5.190-00				5.193	44¼	45¾
5.200-10	5.202	48	42			
5.210-20				5.216	44½	45½
5.220-30	5.223	48¼	41¾			
5.230-40				5.239	44¾	45¼
5.240-50	5.243	48½	41½			
5.250-60						
5.260-70	5.263	48¾	41¼	5.262	45	45
5.270-80						
5.280-90	5.283	49	41	5.285	45¼	44¾
5.290-00						
5.300-10	5.302	49¼	40¾	5.308	45½	44½
5.310-20						
5.320-30	5.323	49½	40½			
5.330-40				5.331	45¾	44¼
5.340-50	5.342	49¾	40¼			
5.350-60				5.353	46	44
5.360-70	5.362	50	40			
5.370-80				5.375	46¼	43¾
5.380-90	5.382	50¼	39¾			
5.390-00				5.398	[illegible]	[illegible]

Approximate Lead	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.100-10						
5.110-20	5.117	40¼	49¾	5.114	37½	52½
5.120-30						
5.130-40						
5.140-50	5.144	40½	49½	5.143	37¾	52¼
5.150-60						
5.160-70						
5.170-80	5.170	40¾	49¼	5.172	38	52
5.180-90						
5.190-00	5.196	41	49			
5.200-10				5.200	38¼	51¾
5.210-20						
5.220-30	5.222	41¼	48¾	5.229	38½	51½
5.230-40						
5.240-50	5.248	41½	48½			
5.250-60				5.258	38¾	51¼
5.260-70						
5.270-80	5.273	41¾	48¼			
5.280-90				5.286	39	51
5.290-00						
5.300-10	5.300	42	48			
5.310-20				5.315	39¼	50¾
5.320-30	5.326	42¼	47¾			
5.330-40						
5.340-50				5.343	39½	50½
5.350-60	5.350	42½	47½			
5.360-70						
5.370-80	5.376	42¾	47¼	5.371	39¾	50¼
5.380-90						
5.390-00				5.400	40	50

LEADS FROM 5.400 TO 5.700

Approximate Lead	Gear on Worm 100, 1st on Stud 48, 2nd on Stud 24, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.400-10	5.400	68¼	21¾				5.405	55¼	34¾	5.401	50½	39½
5.410-20	5.419	68¾	21¼	5.410	61¼	28¾						
5.420-30	5.428	69	21	5.423	61½	28½	5.421	55½	34½	5.421	50¾	39¼
5.430-40	5.437	69¼	20¾	5.436	61¾	28¼	5.437	55¾	34¼			
5.440-50	5.446	69½	20½	5.448	62	28				5.440	51	39
5.450-60	5.455	69¾	20¼				5.454	56	34	5.459	51¼	38¾
5.460-70	5.464	70	20	5.461	62¼	27¾	5.469	56¼	33¾			
5.470-80	5.472	70¼	19¾	5.473	62½	27½				5.478	51½	38½
5.480-90	5.489	70¾	19¼	5.486	62¾	27¼	5.486	56½	33½			
5.490-00	5.497	71	19	5.498	63	27				5.497	51¾	38¼
5.500-10	5.505	71¼	18¾				5.501	56¾	33¼			
5.510-20	5.513	71½	18½	5.510	63¼	26¾	5.517	57	33	5.516	52	38
5.520-30	5.521	71¾	18¼	5.522	63½	26½						
5.530-40	5.537	72¼	17¾	5.534	63¾	26¼	5.532	57¼	32¾	5.535	52¼	37¾
5.540-50	5.545	72½	17½	5.546	64	26	5.548	57½	32½			
5.550-60	5.552	72¾	17¼	5.558	64¼	25¾				5.553	52½	37½
5.560-70	5.560	73	17				5.563	57¾	32¼			
5.570-80	5.574	73½	16½	5.570	64½	25½	5.578	58	32	5.572	52¾	37¼
5.580-90	5.588	74	16	5.581	64¾	25¼						
5.590-00	5.595	74¼	15¾	5.592	65	25	5.594	58¼	31¾	5.590	53	37
5.600-10	5.602	74½	15½	5.604	65¼	24¾	5.608	58½	31½	5.609	53¼	36¾
5.610-20	5.616	75	15	5.615	65½	24½						
5.620-30	5.629	75½	14½	5.626	65¾	24¼	5.623	58¾	31¼	5.627	53½	36½
5.630-40	5.635	75¾	14¼	5.637	66	24	5.638	59	31			
5.640-50	5.641	76	14	5.648	66¼	23¾				5.645	53¾	36¼
5.650-60	5.659	76¾	13¼	5.658	66½	23½	5.653	59¼	30¾			
5.660-70	5.662	77	13				5.667	59½	30½	5.663	54	36
5.670-80	5.676	77½	12½	5.670	66¾	23¼						
5.680-90	5.687	78	12	5.680	67	23	5.682	59¾	30¼	5.681	54¼	35¾
5.690-00	5.692	78¼	11¾	5.691	67¼	22¾	5.698	60	30	5.699	54½	35½

Approximate Lead	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 24, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.400-10				5.401	43	47						
5.410-20												
5.420-30	5.420	46¾	43¼	5.427	43¼	46¾	5.427	40¼	49¾	5.423	37¼	52¾
5.430-40												
5.440-50	5.443	47	43									
5.450-60				5.451	43½	46½	5.455	40½	49½	5.454	37½	52½
5.460-70	5.465	47¼	42¾									
5.470-80				5.477	43¾	46¼						
5.480-90	5.487	47½	42½				5.483	40¾	49¼	5.485	37¾	52¼
5.490-00												
5.500-10	5.509	47¾	42¼	5.501	44	46						
5.510-20							5.511	41	49	5.516	38	52
5.520-30				5.527	44¼	45¾						
5.530-40	5.530	48	42				5.538	41¼	48¾			
5.540-50										5.547	38¼	51¾
5.550-60	5.552	48¼	41¾	5.550	44½	45½						
5.560-70							5.565	41½	48½			
5.570-80	5.574	48½	41½	5.576	44¾	45¼				5.577	38½	51½
5.580-90												
5.590-00	5.595	48¾	41¼				5.593	41¾	48¼			
5.600-10				5.600	45	45				5.607	38¾	51¼
5.610-20	5.616	49	41									
5.620-30				5.624	45¼	44¾	5.621	42	48			
5.630-40	5.637	49¼	40¾							5.638	39	51
5.640-50				5.649	45½	44½	5.648	42¼	47¾			
5.650-60	5.659	49½	40½									
5.660-70										5.668	39¼	50¾
5.670-80				5.673	45¾	44¼	5.675	42½	47½			
5.680-90	5.680	49¾	40¼									
5.690-00				5.697	46	44				5.699	39½	50½

LEADS FROM 5.700 TO 6.000

Approximate Lead	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 56, 2nd on Stud 44, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 24, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 40, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
5.700-10	5.701	67½	22½							5.701	50	40				5.702	42¾	47¼						
5.710-20	5.711	67¾	22¼	5.711	60¼	29¾	5.716	54¾	35¼															
5.720-30	5.722	68	22	5.726	60½	29½				5.722	50¼	39¾	5.721	46¼	43¾	5.729	43	47	5.729	39¾	50¼			
5.730-40	5.731	68¼	21¾	5.739	60¾	29¼	5.734	55	35													5.732	37	53
5.740-50	5.741	68½	21½							5.742	50½	39½	5.745	46½	43½									
5.750-60	5.751	68¾	21¼	5.753	61	29	5.759	55¼	34¾							5.756	43¼	46¾	5.759	40	50			
5.760-70	5.761	69	21	5.767	61¼	28¾	5.769	55½	34½	5.763	50¾	39¼	5.766	46¾	43¼							5.765	37¼	52¾
5.770-80	5.771	69¼	20¾																					
5.780-90	5.780	69½	20½	5.781	61½	28½	5.786	55¾	34¼	5.784	51	39				5.782	43½	46½	5.788	40¼	49¾			
5.790-00	5.799	70	20	5.792	61¾	28¼							5.792	47	43							5.798	37½	52½
5.800-10	5.808	70¼	19¾	5.808	62	28	5.804	56	34	5.804	51¼	38¾				5.808	43¾	46¼						
5.810-20	5.817	70½	19½										5.816	47¼	42¾				5.818	40½	49½			
5.820-30	5.826	70¾	19¼	5.822	62¼	27¾	5.820	56¼	33¾	5.824	51½	38½												
5.830-40	5.835	71	19	5.834	62½	27½	5.837	56½	33½							5.835	44	46				5.8307	37¾	52¼
5.840-50	5.843	71¼	18¾	5.848	62¾	27¼				5.844	51¾	38¼	5.840	47½	42½				5.848	40¾	49¼			
5.850-60	5.852	71½	18½				5.854	56¾	33¼															
5.860-70	5.860	71¾	18¼	5.861	63	27				5.864	52	38	5.863	47¾	42¼	5.862	44¼	45¾				5.863	38	52
5.870-80	5.877	72¼	17¾	5.874	63¼	26¾	5.871	57	33										5.877	41	49			
5.880-90	5.885	72½	17½	5.886	63½	26½	5.887	57¼	32¾	5.884	52¼	37¾	5.886	48	42	5.888	44½	45½						
5.890-00	5.893	72¾	17¼	5.899	63¾	26¼																5.896	38¼	51¾
5.900-10	5.901	73	17				5.904	57½	32½	5.904	52½	37½	5.909	48¼	41¾				5.907	41¼	48¾			
5.910-20	5.916	73½	16½	5.912	64	26										5.914	44¾	45¼						
5.920-30	5.924	73¾	16¼	5.924	64¼	25¾	5.920	57¾	32¼	5.924	52¾	37¼										5.928	38½	51½
5.930-40	5.932	74	16	5.937	64½	25½	5.936	58	32				5.932	48½	41½				5.936	41½	48½			
5.940-50	5.946	74½	15½	5.949	64¾	25¼				5.944	53	37				5.940	45	45						
5.950-60	5.954	74¾	15¼				5.952	58¼	31¾				5.954	48¾	41¼									
5.960-70	5.967	75¼	14¾	5.961	65	25	5.968	58½	31½	5.963	53¼	36¾				5.966	45¼	44¾	5.965	41¾	48¼	5.960	38¾	51¼
5.970-80	5.974	75½	14½	5.974	65¼	24¾							5.977	49	41									
5.980-90	5.981	75¾	14¼	5.986	65½	24½	5.984	58¾	31¼	5.982	53½	36½												
5.990-00	5.988	76	14	5.997	65¾	24¼										5.991	45½	44½	5.995	42	48	5.994	39	51

LEADS FROM 6.000 TO 6.600

Approximate Lead	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 40, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 24, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 40, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 32, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
6.000-20	6.000	59	31	6.002	53¾	36¼	6.000	49¼	40¾	6.017	45¾	44¼							6.008	36½	53½	6.011	34	56
6.020-40	6.031	59½	30½	6.021	54	36	6.022	49½	40½				6.024	42¼	47¾	6.026	39¼	50¾						
6.040-60	6.047	59¾	30¼	6.040	54¼	35¾	6.044	49¾	40¼	6.043	46	44	6.052	42½	47½	6.058	39½	50½	6.044	36¾	53¼	6.050	34¼	55¾
6.060-80	6.062	60	30	6.077	54¾	35¼	6.067	50	40	6.068	46¼	43¾							6.079	37	53			
6.080-00	6.093	60½	29½	6.096	55	35	6.089	50¼	39¾	6.093	46½	43½	6.081	42¾	47¼	6.090	39¾	50¼				6.089	34½	55½
6.100-20	6.108	60¾	29¼	6.115	55¼	34¾	6.111	50½	39½	6.118	46¾	43¼	6.110	43	47				6.114	37¼	52¾			
6.120-40	6.122	61	29	6.134	55½	34½	6.133	50¾	39¼				6.138	43¼	46¾	6.122	40	50				6.128	34¾	55¼
6.140-60	6.152	61½	28½	6.152	55¾	34¼	6.155	51	39	6.143	47	43				6.154	40¼	49¾	6.149	37½	52½			
6.160-80	6.166	61¾	28¼	6.170	56	34	6.177	51¼	38¾	6.168	47¼	42¾	6.167	43½	46½							6.166	35	55
6.180-00	6.181	62	28	6.188	56¼	33¾	6.198	51½	38½	6.193	47½	42½	6.195	43¾	46¼	6.185	40½	49½	6.184	37¾	52¼			
6.200-20	6.209	62½	27½	6.206	56½	33½				6.218	47¾	42¼				6.217	40¾	49¼	6.219	38	52	6.204	35¼	54¾
6.220-40	6.237	63	27	6.224	56¾	33¼	6.220	51¾	38¼				6.223	44	46									
6.240-60	6.251	63¼	26¾	6.242	57	33	6.241	52	38	6.242	48	42	6.251	44¼	45¾	6.248	41	49	6.254	38¼	51¾	6.243	35½	54½
6.260-80	6.265	63½	26½	6.276	57½	32½	6.262	52¼	37¾	6.267	48¼	41¾	6.279	44½	45½									
6.280-00	6.292	64	26	6.294	57¾	32¼	6.283	52½	37½	6.291	48½	41½				6.280	41¼	48¾	6.288	38½	51½	6.281	35¾	54¼
6.300-20	6.318	64½	25½	6.312	58	32	6.304	52¾	37¼	6.315	48¾	41¼	6.307	44¾	45¼	6.311	41½	48½				6.319	36	54
6.320-40	6.331	64¾	25¼	6.329	58¼	31¾	6.325	53	37				6.335	45	45				6.322	38¾	51¼			
6.340-60	6.344	65	25	6.346	58½	31½	6.346	53¼	36¾	6.340	49	41				6.342	41¾	48¼	6.357	39	51	6.357	36¼	53¾
6.360-80	6.370	65½	24½	6.379	59	31	6.367	53½	36½	6.364	49¼	40¾	6.362	45¼	44¾	6.373	42	48						
6.380-00	6.395	66	24	6.396	59¼	30¾	6.387	53¾	36¼	6.387	49½	40½	6.390	45½	44½				6.391	39¼	50¾	6.395	36½	53½
6.400-20	6.419	66½	23½	6.412	59½	30½	6.407	54	36	6.411	49¾	40¼	6.417	45¾	44¼	6.404	42¼	47¾						
6.420-40	6.432	66¾	23¼	6.429	59¾	30¼	6.428	54¼	35¾	6.435	50	40				6.434	42½	47½	6.425	39½	50½	6.432	36¾	53¼
6.440-60	6.444	67	23	6.445	60	30	6.448	54½	35½	6.458	50¼	39¾	6.444	46	44				6.459	39¾	50¼			
6.460-80	6.468	67½	22½	6.477	60½	29½	6.468	54¾	35¼				6.471	46¼	43¾	6.465	42¾	47¼				6.470	37	53
6.480-00	6.490	68	22	6.493	60¾	29¼	6.488	55	35	6.482	50½	39½	6.498	46½	43½	6.495	43	47	6.493	40	50			
6.500-20	6.513	68½	21½	6.509	61	29	6.507	55¼	34¾	6.505	50¾	39¼										6.507	37¼	52¾
6.520-40	6.535	69	21	6.525	61¼	28¾	6.527	55½	34½	6.528	51	39	6.525	46¾	43¼	6.526	43¼	46¾	6.526	40¼	49¾			
6.540-60	6.557	69½	20½	6.540	61½	28½	6.547	55¾	34¼	6.551	51¼	38¾	6.551	47	43	6.556	43½	46½				6.544	37½	52½
6.560-80	6.578	70	20	6.571	62	28	6.566	56	34	6.574	51½	38½	6.578	47¼	42¾				6.560	40½	49½			
6.580-00	6.599	70½	19½	6.586	62¼	27¾	6.585	56¼	33¾	6.597	51¾	38¼				6.586	43¾	46¼	6.594	40¾	49¼	6.582	37¾	52¼

LEADS FROM 6.600 TO 7.200

Approximate Lead	Gear on Worm 56, 1st on Stud 28, 2nd on Stud 32, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 24, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 40, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 32, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
6.600-20	6.601	62½	27½	6.604	56½	33½	6.619	52	38	6.604	47½	42½	6.616	44	46				6.619	38	52	6.618	35¼	54¾
6.620-40	6.631	63	27	6.623	56¾	33¼				6.631	47¾	42¼				6.627	41	49						
6.640-60	6.645	63¼	26¾	6.642	57	33	6.642	52¼	37¾	6.657	48	42	6.646	44¼	45¾				6.655	38¼	51¾	6.659	35½	54½
6.660-80	6.660	63½	26½	6.661	57¼	32¾	6.664	52½	37½				6.675	44½	45½	6.660	41¼	48¾						
6.680-00	6.689	64	26	6.680	57½	32½	6.686	52¾	37¼	6.684	48¼	41¾				6.693	41½	48½	6.692	38½	51½			
6.700-20	6.717	64½	25½	6.717	58	32	6.709	53	37	6.710	48½	41½	6.705	44¾	45¼							6.700	35¾	54¼
6.720-40	6.731	64¾	25¼	6.735	58¼	31¾	6.731	53¼	36¾	6.735	48¾	41¼	6.734	45	45	6.726	41¾	48¼	6.728	38¾	51¼			
6.740-60	6.745	65	25	6.753	58½	31½	6.752	53½	36½							6.759	42	48				6.740	36	54
6.760-80	6.772	65½	24½	6.771	58¾	31¼	6.774	53¾	36¼	6.761	49	41	6.764	45¼	44¾				6.766	39	51			
6.780-00	6.799	66	24	6.789	59	31	6.796	54	36	6.786	49¼	40¾	6.793	45½	44½	6.792	42¼	47¾				6.781	36¼	53¾
6.800-20	6.812	66¼	23¾	6.807	59¼	30¾	6.817	54¼	35¾	6.812	49½	40½							6.802	39¼	50¾			
6.820-40	6.825	66½	23½	6.824	59½	30½	6.839	54½	35½	6.837	49¾	40¼	6.822	45¾	44¼	6.824	42½	47½	6.838	39½	50½	6.821	36½	53½
6.840-60	6.850	67	23	6.859	60	30							6.851	46	44	6.856	42¾	47¼						
6.860-80	6.875	67½	22½	6.876	60¼	29¾	6.860	54¾	35¼	6.862	50	40							6.874	39¾	50¼	6.861	36¾	53¼
6.880-00	6.888	67¾	22¼	6.893	60½	29½	6.881	55	35	6.887	50¼	39¾	6.880	46¼	43¾	6.889	43	47						
6.900-20	6.900	68	22	6.910	60¾	29¼	6.902	55¼	34¾	6.912	50½	39½	6.908	46½	43½				6.910	40	50	6.901	37	53
6.920-40	6.924	68½	21½	6.927	61	29	6.923	55½	34½	6.937	50¾	39¼	6.937	46¾	43¼	6.921	43¼	46¾						
6.940-60	6.948	69	21	6.944	61¼	28¾	6.943	55¾	34¼							6.953	43½	46½	6.946	40¼	49¾	6.941	37¼	52¾
6.960-80	6.971	69½	20½	6.960	61½	28½	6.964	56	34	6.962	51	39	6.965	47	43									
6.980-00	6.993	70	20	6.993	62	28	6.984	56¼	33¾	6.986	51¼	38¾	6.993	47¼	42¾	6.985	43¾	46¼	6.981	40½	49½	6.981	37½	52½
7.000-20	7.015	70½	19½	7.009	62¼	27¾	7.005	56½	33½	7.011	51½	38½				7.017	44	46	7.017	40¾	49¼			
7.020-40	7.036	71	19	7.025	62½	27½	7.025	56¾	33¼	7.035	51¾	38¼	7.022	47½	42½							7.020	37¾	52¼
7.040-60	7.057	71½	18½	7.057	63	27	7.045	57	33	7.059	52	38	7.050	47¾	42¼	7.048	44¼	45¾	7.052	41	49			
7.060-80	7.078	72	18	7.072	63¼	26¾	7.065	57¼	32¾				7.078	48	42							7.060	38	52
7.080-00	7.097	72½	17½	7.088	63½	26½	7.085	57½	32½	7.083	52¼	37¾				7.080	44½	45½	7.088	41¼	48¾	7.099	38¼	51¾
7.100-20	7.117	73	17	7.118	64	26	7.104	57¾	32¼	7.107	52½	37½	7.105	48¼	41¾	7.111	44¾	45¼						
7.120-40	7.135	73½	16½	7.134	64¼	25¾	7.124	58	32	7.131	52¾	37¼	7.133	48½	41½				7.124	41½	48½	7.138	38½	51½
7.140-60	7.154	74	16	7.149	64½	25½	7.143	58¼	31¾	7.155	53	37				7.143	45	45	7.158	41¾	48¼			
7.160-80	7.171	74½	15½	7.178	65	25	7.162	58½	31½	7.178	53¼	36¾	7.160	48¾	41¼	7.174	45¼	44¾				7.177	38¾	51¼
7.180-00	7.188	75	15	7.192	65¼	24¾	7.181	58¾	31¼				7.188	49	41				7.19[illegible]	[illegible]	48			

LEADS FROM 7.200 TO 7.800

Approximate Lead	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 32, 2nd on Stud 48, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 24, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 40, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
7.200-20	7.207	65½	24½	7.219	59¼	30¾	7.201	53½	36½	7.215	49¼	40¾
7.220-40	7.235	66	24	7.238	59½	30½	7.224	53¾	36¼			
7.240-60	7.249	66¼	23¾	7.256	59¾	30¼	7.248	54	36	7.242	49½	40½
7.260-80	7.263	66½	23½	7.275	60	30	7.270	54¼	35¾	7.269	49¾	40¼
7.280-00	7.290	67	23	7.293	60¼	29¾	7.293	54½	35½	7.296	50	40
7.300-20	7.304	67¼	22¾	7.311	60½	29½	7.316	54¾	35¼			
7.320-40	7.330	67¾	22¼	7.329	60¾	29¼	7.338	55	35	7.322	50¼	39¾
7.340-60	7.343	68	22	7.347	61	29				7.349	50½	39½
7.360-80	7.369	68½	21½	7.365	61¼	28¾	7.361	55¼	34¾	7.375	50¾	39¼
7.380-00	7.394	69	21	7.382	61½	28½	7.383	55½	34½			
7.400-20	7.418	69½	20½	7.417	62	28	7.405	55¾	34¼	7.401	51	39
7.420-40	7.430	69¾	20¼	7.434	62¼	27¾	7.427	56	34	7.427	51¼	38¾
7.440-60	7.442	70	20	7.451	62½	27½	7.449	56¼	33¾	7.453	51½	38½
7.460-80	7.466	70½	19½	7.468	62¾	27¼	7.471	56½	33½	7.479	51¾	38¼
7.480-00	7.489	71	19	7.484	63	27	7.492	56¾	33¼			
7.500-20	7.511	71½	18½	7.517	63½	26½	7.513	57	33	7.505	52	38
7.520-40	7.532	72	18	7.534	63¾	26¼	7.534	57¼	32¾	7.530	52¼	37¾
7.540-60	7.543	72¼	17¾	7.550	64	26	7.555	57½	32½	7.556	52½	37½
7.560-80	7.574	73	17	7.566	64¼	25¾	7.576	57¾	32¼			
7.580-00	7.594	73½	16½	7.582	64½	25½	7.597	58	32	7.581	52¾	37¼
7.600-20	7.613	74	16	7.613	65	25	7.618	58¼	31¾	7.606	53	37
7.620-40	7.632	74½	15½	7.628	65¼	24¾	7.638	58½	31½	7.631	53¼	36¾
7.640-60	7.650	75	15	7.644	65½	24½	7.659	58¾	31¼	7.656	53½	36½
7.660-80	7.668	75½	14½	7.674	66	24	7.679	59	31			
7.680-00	7.685	76	14	7.689	66¼	23¾	7.699	59¼	30¾	7.680	53¾	36¼
7.700-20	7.717	77	13	7.703	66½	23½	7.719	59½	30½	7.705	54	36
7.720-40	7.725	77¼	12¾	7.732	67	23	7.739	59¾	30¼	7.729	54¼	35¾
7.740-60	7.747	78	12	7.746	67¼	22¾	7.758	60	30	7.754	54½	35½
7.760-80	7.775	79	11	7.760	67½	22½	7.778	60¼	29¾	7.778	54¾	35¼
7.780-00	7.787	79½	10½	7.788	68	22	7.797	60½	29½			

Approximate Lead	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 32, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
7.200-20	7.204	45½	44½				7.216	39	51	7.201	36¼	53¾
7.220-40	7.235	45¾	44¼	7.228	42¼	47¾						
7.240-60							7.255	39¼	50¾	7.244	36½	53½
7.260-80	7.266	46	44	7.263	42½	47½						
7.280-00	7.297	46¼	43¾	7.297	42¾	47¼	7.294	39½	50½	7.286	36¾	53¼
7.300-20												
7.320-40	7.327	46½	43½	7.332	43	47	7.332	39¾	50¼	7.329	37	53
7.340-60	7.357	46¾	43¼									
7.360-80				7.366	43¼	46¾	7.370	40	50	7.371	37¼	52¾
7.380-00	7.387	47	43									
7.400-20	7.418	47¼	42¾	7.400	43½	46½	7.408	40¼	49¾	7.413	37½	52½
7.420-40				7.434	43¾	46¼						
7.440-60	7.447	47½	42½				7.446	40½	49½	7.455	37¾	52¼
7.460-80	7.477	47¾	42¼	7.467	44	46						
7.480-00							7.484	40¾	49¼	7.497	38	52
7.500-20	7.506	48	42	7.501	44¼	45¾						
7.520-40	7.536	48¼	41¾	7.535	44½	45½	7.522	41	49	7.539	38¼	51¾
7.540-60												
7.560-80	7.565	48½	41½	7.568	44¾	45¼	7.560	41¼	48¾			
7.580-00	7.594	48¾	41¼				7.598	41½	48½	7.580	38½	51½
7.600-20				7.602	45	45						
7.620-40	7.624	49	41	7.634	45¼	44¾	7.636	41¾	48¼	7.622	38¾	51¼
7.640-60	7.652	49¼	40¾									
7.660-80				7.668	45½	44½	7.672	42	48	7.664	39	51
7.680-00	7.681	49½	40½									
7.700-20	7.710	49¾	40¼	7.700	45¾	44¼	7.710	42¼	47¾	7.704	39¼	50¾
7.720-40	7.738	50	40	7.733	46	44						
7.740-60							7.746	42½	47½	7.746	39½	50½
7.760-80	7.766	50¼	39¾	7.765	46¼	43¾						
7.780-00	7.794	50½	39½	7.798	46½	43½	7.783	42¾	47¼	7.787	39¾	50¼

LEADS FROM 7.800 TO 8.400

Approximate Lead	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 24, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 40, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 32, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
7.800-20	7.816	60¾	29¼	7.801	55	35													7.802	37	53			
7.820-40	7.835	61	29	7.825	55¼	34¾	7.822	50¾	39¼	7.830	46¾	43¼	7.820	43	47	7.827	40	50						
7.840-60	7.854	61¼	28¾	7.849	55½	34½	7.850	51	39				7.856	43¼	46¾				7.846	37¼	52¾	7.843	34¾	55¼
7.860-80	7.873	61½	28½	7.872	55¾	34¼	7.877	51¼	38¾	7.862	47	43				7.868	40¼	49¾						
7.880-00	7.891	61¾	28¼	7.896	56	34				7.894	47¼	42¾	7.893	43½	46½				7.891	37½	52½	7.892	35	55
7.900-20	7.910	62	28	7.919	56¼	33¾	7.905	51½	38½							7.908	40½	49½						
7.920-40	7.928	62¼	27¾				7.932	51¾	38¼	7.926	47½	42½	7.928	43¾	46¼				7.936	37¾	52¼			
7.940-60	7.946	62½	27½	7.942	56½	33½				7.958	47¾	42¼				7.948	40¾	49¼				7.942	35¼	54¾
7.960-80	7.964	62¾	27¼	7.965	56¾	33¼	7.960	52	38				7.965	44	46									
7.980-00	7.982	63	27	7.987	57	33	7.987	52¼	37¾	7.989	48	42				7.989	41	49	7.981	38	52	7.990	35½	54½
8.000-20	8.017	63½	26½	8.010	57¼	32¾	8.014	52½	37½				8.001	44¼	45¾									
8.020-40	8.034	63¾	26¼	8.032	57½	32½				8.020	48¼	41¾	8.037	44½	45½	8.029	41¼	48¾	8.026	38¼	51¾			
8.040-60	8.052	64	26	8.055	57¾	32¼	8.040	52¾	37¼	8.052	48½	41½										8.040	35¾	54¼
8.060-80	8.069	64¼	25¾	8.077	58	32	8.067	53	37				8.072	44¾	45¼	8.069	41½	48½	8.070	38½	51½			
8.080-00	8.086	64½	25½	8.099	58¼	31¾	8.094	53¼	36¾	8.082	48¾	41¼										8.088	36	54
8.100-20	8.119	65	25							8.113	49	41	8.108	45	45	8.109	41¾	48¼	8.114	38¾	51¼			
8.120-40	8.136	65¼	24¾	8.120	58½	31½	8.120	53½	36½													8.137	36¼	53¾
8.140-60	8.152	65½	24½	8.142	58¾	31¼	8.146	53¾	36¼	8.144	49¼	40¾	8.143	45¼	44¾	8.148	42	48	8.158	39	51			
8.160-80	8.168	65¾	24¼	8.163	59	31	8.172	54	36	8.174	49½	40½	8.178	45½	44½									
8.180-00	8.184	66	24	8.185	59¼	30¾	8.198	54¼	35¾							8.188	42¼	47¾				8.185	36½	53½
8.200-20	8.216	66½	23½	8.206	59½	30½				8.205	49¾	40¼	8.213	45¾	44¼				8.202	39¼	50¾			
8.220-40	8.230	66¾	23¼	8.227	59¾	30¼	8.224	54½	35½	8.235	50	40				8.226	42½	47½				8.233	36¾	53¼
8.240-60	8.246	67	23	8.248	60	30	8.249	54¾	35¼				8.248	46	44				8.246	39½	50½			
8.260-80	8.277	67½	22½	8.269	60¼	29¾	8.274	55	35	8.265	50¼	39¾				8.266	42¾	47¼						
8.280-00	8.292	67¾	22¼	8.289	60½	29½				8.295	50½	39½	8.282	46¼	43¾				8.289	39¾	50¼	8.281	37	53
8.300-20	8.306	68	22	8.310	60¾	29¼	8.300	55¼	34¾				8.317	46½	43½	8.305	43	47						
8.320-40	8.335	68½	21½	8.330	61	29	8.324	55½	34½	8.324	50¾	39¼							8.332	40	50	8.329	37¼	52¾
8.340-60	8.350	68¾	21¼	8.350	61¼	28¾	8.349	55¾	34¼	8.354	51	39	8.351	46¾	43¼	8.343	43¼	46¾						
8.360-80	8.364	69	21	8.370	61½	28½	8.374	56	34										8.375	40¼	49¾	8.376	37½	52½
8.380-00	8.392	69½	20½	8.389	61¾	28¼	8.398	56½	33½	8.384	51¼	38¾	8.386	47	43	8.382	43½	46½						

LEADS FROM 8.400 TO

Approximate Lead	Gear on Worm 64, 1st on Stud 48, 2nd on Stud 40, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 32, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
8.400-20	8.409	62	28				8.413	51½	38½			
8.420-40	8.428	62¼	27¾	8.424	56½	33½				8.420	47¼	42¾
8.440-60	8.448	62½	27½	8.448	56¾	33¼	8.443	51¾	38¼	8.454	47½	42½
8.460-80	8.467	62¾	27¼	8.472	57	33	8.471	52	38			
8.480-00	8.486	63	27	8.496	57¼	32¾				8.488	47¾	42¼
8.500-20	8.504	63¼	26¾	8.519	57½	32½	8.500	52¼	37¾			
8.520-40	8.523	63½	26½				8.529	52½	37½	8.521	48	42
8.540-60	8.542	63¾	26¼	8.543	57¾	32¼	8.557	52¾	37¼	8.555	48¼	41¾
8.560-80	8.560	64	26	8.566	58	32						
8.580-00	8.596	64½	25½	8.590	58¼	31¾	8.585	53	37	8.588	48½	41½
8.600-20	8.614	64¾	25¼	8.612	58½	31½	8.614	53¼	36¾			
8.620-40	8.632	65	25	8.636	58¾	31¼				8.621	48¾	41¼
8.640-60	8.649	65¼	24¾	8.658	59	31	8.642	53½	36½	8.654	49	41
8.660-80	8.666	65½	24½				8.670	53¾	36¼			
8.680-00	8.684	65¾	24¼	8.681	59¼	30¾	8.697	54	36	8.686	49¼	40¾
8.700-20	8.701	66	24	8.703	59½	30½				8.719	49½	40½
8.720-40	8.734	66½	23½	8.726	59¾	30¼	8.724	54¼	35¾			
8.740-60	8.750	66¾	23¼	8.748	60	30	8.752	54½	35½	8.751	49¾	40¼
8.760-80	8.766	67	23	8.770	60¼	29¾	8.779	54¾	35¼			
8.780-00	8.799	67½	22½	8.791	60½	29½				8.784	50	40
8.800-20	8.815	67¾	22¼	8.813	60¾	29¼	8.806	55	35	8.815	50¼	39¾
8.820-40	8.830	68	22	8.834	61	29	8.832	55¼	34¾			
8.840-60	8.846	68¼	21¾	8.856	61¼	28¾				8.847	50½	39½
8.860-80	8.861	68½	21½	8.877	61½	28½	8.860	55½	34½	8.879	50¾	39¼
8.880-00	8.891	69	21	8.898	61¾	28¼	8.886	55¾	34¼			
8.900-20	8.906	69¼	20¾	8.919	62	28	8.912	56	34	8.910	51	39
8.920-40	8.921	69½	20½				8.938	56¼	33¾			
8.940-60	8.949	70	20	8.940	62¼	27¾				8.942	51¼	38¾
8.960-80	8.978	70½	19½	8.960	62½	27½	8.965	56½	33½	8.974	51½	38½
8.980-00	8.991	70¾	19¼	8.980	62¾	27¼	8.990	56¾	33¼			

Approximate Lead	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
8.400-20				8.419	40½	49½				8.408	35	55
8.420-40	8.420	43¾	46¼				8.424	37¾	52¼			
8.440-60	8.459	44	46									
8.460-80				8.462	40¾	49¼	8.471	38	52	8.460	35¼	54¾
8.480-00	8.497	44¼	45¾									
8.500-20				8.505	41	49	8.519	38¼	51¾	8.513	35½	54½
8.520-40	8.536	44½	45½									
8.540-60				8.547	41¼	48¾						
8.560-80	8.573	44¾	45¼				8.566	38½	51½	8.565	35¾	54¼
8.580-00				8.590	41½	48½						
8.600-20	8.611	45	45				8.613	38¾	51¼	8.618	36	54
8.620-40				8.632	41¾	48¼						
8.640-60	8.648	45¼	44¾									
8.660-80				8.674	42	48	8.660	39	51	8.669	36¼	53¾
8.680-00	8.686	45½	44½									
8.700-20				8.716	42¼	47¾	8.706	39¼	50¾			
8.720-40	8.723	45¾	44¼							8.720	36½	53½
8.740-60				8.758	42½	47½	8.752	39½	50½			
8.760-80	8.760	46	44							8.771	36¾	53¼
8.780-00	8.796	46¼	43¾	8.799	42¾	47¼	8.799	39¾	50¼			
8.800-20												
8.820-40	8.833	46½	43½							8.822	37	53
8.840-60				8.841	43	47	8.844	40	50			
8.860-80	8.869	46¾	43¼							8.873	37¼	52¾
8.880-00				8.882	43¼	46¾	8.890	40¼	49¾			
8.900-20	8.906	47	43									
8.920-40				8.924	43½	46½	8.936	40½	49½	8.924	37½	52½
8.940-60	8.942	47¼	42¾									
8.960-80	8.978	47½	42½	8.964	43¾	46¼				8.975	37¾	52¼
8.980-00							8.982	40¾	49¼			

LEADS FROM 9.000 TO 9.600

Approximate Lead	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 32, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
9.000-20	9.000	63	27	9.016	57	33	9.004	51¾	38¼	9.014	47¾	42¼
9.020-40	9.020	63¼	26¾				9.036	52	38			
9.040-60	9.040	63½	26½	9.042	57¼	32¾				9.050	48	42
9.060-80	9.079	64	26	9.067	57½	32½	9.067	52¼	37¾			
9.080-00	9.098	64¼	25¾	9.092	57¾	32¼	9.097	52½	37½	9.086	48¼	41¾
9.100-20	9.117	64½	25½	9.117	58	32						
9.120-40	9.136	64¾	25¼				9.127	52¾	37¼	9.120	48½	41½
9.140-60	9.154	65	25	9.141	58¼	31¾	9.157	53	37	9.156	48¾	41¼
9.160-80	9.173	65¼	24¾	9.166	58½	31½						
9.180-00	9.191	65½	24½	9.190	58¾	31¼	9.187	53¼	36¾	9.190	49	41
9.200-20	9.210	65¾	24¼	9.214	59	31	9.217	53½	36½			
9.220-40	9.228	66	24	9.238	59¼	30¾				9.225	49¼	40¾
9.240-60	9.245	66¼	23¾				9.247	53¾	36¼			
9.260-80	9.263	66½	23½	9.262	59½	30½	9.276	54	36	9.260	49½	40½
9.280-00	9.298	67	23	9.286	59¾	30¼				9.294	49¾	40¼
9.300-20	9.315	67¼	22¾	9.310	60	30	9.305	54¼	35¾			
9.320-40	9.332	67½	22½	9.333	60¼	29¾	9.334	54½	35½	9.328	50	40
9.340-60	9.349	67¾	22¼	9.356	60½	29½						
9.360-80	9.365	68	22	9.379	60¾	29¼	9.364	54¾	35¼	9.362	50¼	39¾
9.380-00	9.398	68½	21½				9.392	55	35	9.396	50½	39½
9.400-20	9.414	68¾	21¼	9.402	61	29						
9.420-40	9.430	69	21	9.425	61¼	28¾	9.421	55¼	34¾	9.430	50¾	39¼
9.440-60	9.446	69¼	20¾	9.448	61½	28½	9.450	55½	34½			
9.460-80	9.462	69½	20½	9.470	61¾	28¼	9.478	55¾	34¼	9.464	51	39
9.480-00	9.492	70	20	9.492	62	28				9.497	51¼	38¾
9.500-20	9.507	70¼	19¾	9.514	62¼	27¾	9.506	56	34			
9.520-40	9.522	70½	19½	9.536	62½	27½	9.534	56¼	33¾	9.530	51½	38½
9.540-60	9.550	71	19	9.548	62¾	27¼						
9.560-80	9.579	71½	18½	9.579	63	27	9.562	56½	33½	9.563	51¾	38¼
9.580-00	9.593	71¾	18¼							9.596	52	38

Approximate Lead	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
9.000-20	9.005	44	46									
9.020-40				9.028	41	49	9.025	38	52	9.034	35½	54½
9.040-60	9.046	44¼	45¾									
9.060-80				9.073	41¼	48¾	9.076	38¼	51¾			
9.080-00	9.086	44½	45½							9.089	35¾	54¼
9.100-20				9.118	41½	48½						
9.120-40	9.126	44¾	45¼				9.126	38½	51½			
9.140-60										9.144	36	54
9.160-80	9.167	45	45	9.163	41¾	48¼	9.175	38¾	51¼			
9.180-00										9.199	36¼	53¾
9.200-20	9.206	45¼	44¾	9.207	42	48						
9.220-40							9.225	39	51			
9.240-60	9.246	45½	44½	9.252	42¼	47¾				9.254	36½	53½
9.260-80							9.275	39¼	50¾			
9.280-00	9.286	45¾	44¼	9.296	42½	47½						
9.300-20										9.308	36¾	53¼
9.320-40	9.325	46	44				9.324	39½	50½			
9.340-60				9.340	42¾	47¼						
9.360-80	9.364	46¼	43¾				9.374	39¾	50¼	9.362	37	53
9.380-00				9.384	43	47						
9.400-20	9.403	46½	43½							9.416	37¼	52¾
9.420-40				9.428	43¼	46¾	9.422	40	50			
9.440-60	9.442	46¾	43¼									
9.460-80				9.472	43½	46½	9.471	40¼	49¾	9.470	37½	52½
9.480-00	9.481	47	43									
9.500-20				9.515	43¾	46¼						
9.520-40	9.520	47¼	42¾				9.520	40½	49½	9.524	37¾	52¼
9.540-60	9.548	47½	42½	9.559	44	46						
9.560-80							9.569	40¾	49¼	9.578	38	52
9.580-00	9.596	47¾	42¼									

Approximate Lead	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 32, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
9.600-20	9.600	63¼	26¾	9.617	57	33						
9.620-40	9.621	63½	26½				9.629	52¼	37¾	9.634	48	42
9.640-60	9.642	63¾	26¼	9.644	57¼	32¾						
9.660-80	9.662	64	26	9.670	57½	32½	9.661	52½	37½	9.672	48¼	41¾
9.680-00	9.683	64¼	25¾	9.697	57¾	32¼	9.693	52¾	37¼			
9.700-20	9.703	64½	25½							9.710	48½	41½
9.720-40	9.723	64¾	25¼	9.724	58	32	9.725	53	37			
9.740-60	9.743	65	25	9.750	58¼	31¾	9.757	53¼	36¾	9.747	48¾	41¼
9.760-80	9.763	65¼	24¾	9.776	58½	31½						
9.780-00	9.782	65½	24½				9.788	53½	36½	9.784	49	41
9.800-20	9.801	65¾	24¼	9.802	58¾	31¼						
9.820-40	9.839	66¼	23¾	9.828	59	31	9.820	53¾	36¼	9.820	49¼	40¾
9.840-60	9.858	66½	23½	9.854	59¼	30¾	9.852	54	36	9.857	49½	40½
9.860-80	9.876	66¾	23¼	9.879	59½	30½						
9.880-00	9.895	67	23				9.882	54¼	35¾	9.894	49¾	40¼
9.900-20	9.914	67¼	22¾	9.904	59¾	30¼	9.914	54½	35½			
9.920-40	9.932	67½	22½	9.930	60	30				9.930	50	40
9.940-60	9.950	67¾	22¼	9.954	60¼	29¾	9.944	54¾	35¼			
9.960-80	9.967	68	22	9.979	60½	29½	9.975	55	35	9.966	50¼	39¾
9.980-00	9.985	68¼	21¾									
10.000-20	10.002	68½	21½	10.004	60¾	29¼	10.006	55¼	34¾	10.002	50½	39½
10.020-40	10.036	69	21	10.028	61	29	10.036	55½	34½	10.038	50¾	39¼
10.040-60	10.053	69¼	20¾	10.053	61¼	28¾						
10.060-80	10.070	69½	20½	10.077	61½	28½	10.066	55¾	34¼	10.074	51	39
10.080-00	10.086	69¾	20¼				10.096	56	34			
10.100-20	10.102	70	20	10.100	61¾	28¼				10.110	51¼	38¾
10.120-40	10.134	70½	19½	10.124	62	28	10.125	56¼	33¾			
10.140-60	10.149	70¾	19¼	10.148	62¼	27¾	10.155	56½	33½	10.146	51½	38½
10.160-80	10.163	71	19	10.170	62½	27½						
10.180-00	10.194	71½	18½	10.190	62¾	27¼	10.184	56¾	33¼	10.180	51¾	38¼

Approximate Lead	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
9.600-20	9.602	44¼	45¾	9.618	41	49						
9.620-40							9.631	38¼	51¾			
9.640-60	9.645	44½	45½							9.641	35¾	54¼
9.660-80				9.666	41¼	48¾						
9.680-00	9.688	44¾	45¼				9.684	38½	51½	9.699	36	54
9.700-20				9.714	41½	48½						
9.720-40	9.730	45	45				9.736	38¾	51¼			
9.740-60										9.757	36¼	53¾
9.760-80	9.772	45¼	44¾	9.762	41¾	48¼						
9.780-00							9.790	39	51			
9.800-20	9.814	45½	44½	9.809	42	48				9.815	36½	53½
9.820-40												
9.840-60	9.856	45¾	44¼	9.846	42¼	47¾	9.842	39¼	50¾			
9.860-80										9.873	36¾	53¼
9.880-00	9.898	46	44				9.895	39½	50½			
9.900-20				9.904	42½	47½						
9.920-40										9.930	37	53
9.940-60	9.940	46¼	43¾	9.950	42¾	47¼	9.947	39¾	50¼			
9.960-80												
9.980-00	9.981	46½	43½	9.997	43	47	9.999	40	50	9.988	37¼	52¾
10.000-20												
10.020-40	10.022	46¾	43¼									
10.040-60				10.044	43¼	46¾	10.050	40¼	49¾	10.045	37½	52½
10.060-80	10.063	47	43									
10.080-00				10.091	43½	46½						
10.100-20	10.104	47¼	42¾				10.102	40½	49½	10.103	37¾	52¼
10.120-40				10.137	43¾	46¼						
10.140-60	10.145	47½	42½				10.154	40¾	49¼	10.159	38	52
10.160-80												
10.180-00	10.186	47¾	42¼	10.183	44	46						

LEADS FROM 10.200 TO 10.800

Approximate Lead	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.200-20	10.217	63	27	10.213	57	33
10.220-40	10.238	63¼	26¾			
10.240-60				10.242	57¼	32¾
10.260-80	10.260	63½	26½	10.270	57½	32½
10.280-00	10.283	63¾	26¼	10.298	57¾	32¼
10.300-20	10.305	64	26			
10.320-40	10.327	64¼	25¾	10.327	58	32
10.340-60	10.349	64½	25½	10.354	58¼	31¾
10.360-80	10.370	64¾	25¼			
10.380-00	10.391	65	25	10.383	58½	31½
10.400-20	10.412	65¼	24¾	10.410	58¾	31¼
10.420-40	10.433	65½	24½	10.438	59	31
10.440-60	10.453	65¾	24¼			
10.460-80	10.474	66	24	10.465	59¼	30¾
10.480-00	10.494	66¼	23¾	10.492	59½	30½
10.500-20	10.515	66½	23½	10.519	59¾	30¼
10.520-40	10.534	66¾	23¼			
10.540-60	10.554	67	23	10.546	60	30
10.560-80	10.574	67¼	22¾	10.572	60¼	29¾
10.580-00	10.593	67½	22½	10.598	60½	29½
10.600-20	10.612	67¾	22¼			
10.620-40	10.630	68	22	10.625	60¾	29¼
10.640-60	10.650	68¼	21¾	10.650	61	29
10.660-80	10.668	68½	21½	10.676	61¼	28¾
10.680-00	10.687	68¾	21¼			
10.700-20	10.704	69	21	10.701	61½	28½
10.720-40	10.722	69¼	20¾	10.727	61¾	28¼
10.740-60	10.740	69½	20½	10.752	62	28
10.760-80	10.775	70	20	10.777	62¼	27¾
10.780-00	10.791	70¼	19¾			

Approximate Lead	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.200-20	10.216	52	38			
10.220-40				10.226	48	42
10.240-60	10.250	52¼	37¾			
10.260-80				10.267	48¼	41¾
10.280-00	10.285	52½	37½			
10.300-20	10.319	52¾	37¼	10.306	48½	41½
10.320-40						
10.340-60	10.353	53	37	10.345	48¾	41¼
10.360-80						
10.380-00	10.387	53¼	36¾	10.384	49	41
10.400-20						
10.420-40	10.420	53½	36½	10.424	49¼	40¾
10.440-60	10.454	53¾	36¼			
10.460-80				10.463	49½	40½
10.480-00	10.488	54	36			
10.500-20				10.501	49¾	40¼
10.520-40	10.520	54¼	35¾			
10.540-60	10.553	54½	35½	10.540	50	40
10.560-80						
10.580-00	10.586	54¾	35¼	10.580	50¼	39¾
10.600-20	10.619	55	35	10.618	50½	39½
10.620-40						
10.640-60	10.651	55¼	34¾	10.655	50¾	39¼
10.660-80						
10.680-00	10.683	55½	34½	10.693	51	39
10.700-20	10.716	55¾	34¼			
10.720-40				10.731	51¼	38¾
10.740-60	10.747	56	34			
10.760-80	10.779	56¼	33¾	10.769	51½	38½
10.780-00						

Approximate Lead	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.200-20				10.206	41	49
10.220-40	10.230	44¼	45¾			
10.240-60				10.257	41¼	48¾
10.260-80	10.274	44½	45½			
10.280-00						
10.300-20				10.308	41½	48½
10.320-40	10.320	44¾	45¼			
10.340-60				10.358	41¾	48¼
10.360-80	10.366	45	45			
10.380-00						
10.400-20	10.410	45¼	44¾	10.409	42	48
10.420-40						
10.440-60	10.455	45½	44½			
10.460-80				10.460	42¼	47¾
10.480-00						
10.500-20	10.500	45¾	44¼	10.509	42½	47½
10.520-40						
10.540-60	10.544	46	44	10.559	42¾	47¼
10.560-80						
10.580-00	10.589	46¼	43¾			
10.600-20				10.609	43	47
10.620-40	10.633	46½	43½			
10.640-60				10.658	43¼	46¾
10.660-80	10.677	46¾	43¼			
10.680-00						
10.700-20				10.708	43½	46½
10.720-40	10.721	47	43			
10.740-60				10.757	43¾	46¼
10.760-80	10.764	47¼	42¾			
10.780-00						

Approximate Lead	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.200-20	10.215	38¼	51¾	10.203	35¼	54¾
10.220-40						
10.240-60						
10.260-80	10.272	38½	51½	10.265	35½	54½
10.280-00						
10.300-20						
10.320-40	10.328	38¾	51¼	10.327	35¾	54¼
10.340-60						
10.360-80						
10.380-00	10.384	39	51	10.390	36	54
10.400-20						
10.420-40						
10.440-60	10.440	39¼	50¾	10.453	36¼	53¾
10.460-80						
10.480-00	10.496	39½	50½			
10.500-20				10.515	36½	53½
10.520-40						
10.540-60	10.551	39¾	50¼			
10.560-80				10.576	36¾	53¼
10.580-00						
10.600-20	10.606	40	50			
10.620-40				10.638	37	53
10.640-60						
10.660-80	10.661	40¼	49¾			
10.680-00						
10.700-20	10.716	40½	49½	10.700	37¼	52¾
10.720-40						
10.740-60						
10.760-80	10.770	40¾	49¼	10.760	37½	52½
10.780-00						

LEADS FROM 10.800 TO …

Approximate Lead	Gear on Worm 86, 1st on Stud 48, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.800-20	10.809	70½	19½	10.801	62½	27½
10.820-40	10.825	70¾	19¼	10.826	62¾	27¼
10.840-60	10.840	71	19	10.850	63	27
10.860-80	10.873	71½	18½	10.875	63¼	26¾
10.880-00	10.889	71¾	18¼	10.898	63½	26½
10.900-20	10.904	72	18			
10.920-40	10.934	72½	17½	10.920	63¾	26¼
10.940-60	10.950	72¾	17¼	10.944	64	26
10.960-80	10.964	73	17	10.967	64¼	25¾
10.980-00	10.992	73½	16½	10.990	64½	25½
11.000-20	11.007	73¾	16¼	11.013	64¾	25¼
11.020-40	11.021	74	16	11.036	65	25
11.040-60	11.049	74½	15½	11.058	65¼	24¾
11.060-80	11.075	75	15			
11.080-00	11.088	75¼	14¾	11.080	65½	24½
11.100-20	11.100	75½	14½	11.102	65¾	24¼
11.120-40	11.125	75	14	11.124	66	24
11.140-60	11.148	76½	13½	11.145	66¼	23¾
11.160-80	11.171	77	13	11.167	66½	23½
11.180-00	11.194	77½	12½	11.187	66¾	23¼
11.200-20	11.215	78	12	11.208	67	23
11.220-40	11.235	78½	11½	11.230	67¼	22¾
11.240-60	11.255	79	11	11.250	67½	22½
11.260-80	11.273	79½	10½	11.270	67¾	22¼
11.280-00	11.292	80	10	11.290	68	22
11.300-20				11.310	68¼	21¾
11.320-40				11.330	68½	21½
11.340-60				11.350	68¾	21¼
11.360-80				11.369	69	21
11.380-00				11.388	69¼	20¾

Approximate Lead	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.800-20	10.810	56½	33½	10.807	51¾	38¼
10.820-40						
10.840-60	10.841	56¾	33¼	10.843	52	38
10.860-80	10.872	57	33			
10.880-00				10.880	52¼	37¾
10.900-20	10.903	57¼	32¾	10.917	52½	37½
10.920-40	10.933	57½	32½			
10.940-60				10.953	52¾	37¼
10.960-80	10.963	57¾	32¼			
10.980-00	10.993	58	32	10.989	53	37
11.000-20						
11.020-40	11.022	58¼	31¾	11.025	53¼	36¾
11.040-60	11.052	58½	31½			
11.060-80				11.060	53½	36½
11.080-00	11.082	58¾	31¼	11.097	53¾	36¼
11.100-20	11.111	59	31			
11.120-40				11.132	54	36
11.140-60	11.140	59¼	30¾			
11.160-80	11.170	59½	30½	11.167	54¼	35¾
11.180-00	11.198	59¾	30¼			
11.200-20				11.202	54½	35½
11.220-40	11.226	60	30	11.237	54¾	35¼
11.240-60	11.254	60¼	29¾			
11.260-80				11.271	55	35
11.280-00	11.282	60½	29½			
11.300-20	11.310	60¾	29¼	11.306	55¼	34¾
11.320-40						
11.340-60	11.338	61	29	11.340	55½	34½
11.360-80	11.366	61¼	28¾	11.374	55¾	34¼
11.380-00						

Approximate Lead	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.800-20	10.807	47½	42½	10.806	44	46
10.820-40						
10.840-60	10.850	47¾	42¼	10.854	44¼	45¾
10.860-80						
10.880-00	10.893	48	42			
10.900-20				10.903	44½	45½
10.920-40	10.937	48¼	41¾			
10.940-60				10.951	44¾	45¼
10.960-80	10.979	48½	41½			
10.980-00						
11.000-20				11.000	45	45
11.020-40	11.021	48¾	41¼			
11.040-60				11.047	45¼	44¾
11.060-80	11.063	49	41			
11.080-00				11.094	45½	44½
11.100-20	11.104	49¼	40¾			
11.120-40						
11.140-60	11.147	49½	40½	11.142	45¾	44¼
11.160-80						
11.180-00	11.188	49¾	40¼	11.190	46	44
11.200-20						
11.220-40	11.230	50	40	11.237	46¼	43¾
11.240-60						
11.260-80	11.270	50¼	39¾			
11.280-00				11.283	46½	43½
11.300-20	11.310	50½	39½			
11.320-40				11.330	46¾	43¼
11.340-60	11.351	50¾	39¼			
11.360-80				11.377	47	43
11.380-00	11.392	51	39			

Approximate Lead	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
10.800-20						
10.820-40	10.825	41	49	10.822	37¾	52¼
10.840-60						
10.860-80						
10.880-00	10.880	41¼	48¾	10.883	38	52
10.900-20						
10.920-40	10.934	41½	48½			
10.940-60				10.944	38¼	51¾
10.960-80						
10.980-00	10.988	41¾	48¼			
11.000-20				11.004	38½	51½
11.020-40						
11.040-60	11.040	42	48			
11.060-80				11.064	38¾	51¼
11.080-00	11.094	42¼	47¾			
11.100-20						
11.120-40				11.124	39	51
11.140-60	11.147	42½	47½			
11.160-80						
11.180-00				11.184	39¼	50¾
11.200-20	11.200	42¾	47¼			
11.220-40						
11.240-60	11.253	43	47	11.244	39½	50½
11.260-80						
11.280-00						
11.300-20	11.306	43¼	46¾	11.303	39¾	50¼
11.320-40						
11.340-60	11.359	43½	46½			
11.360-80				11.362	40	
11.380-00						

LEADS FROM 11.400 TO 12.000

Approximate Lead	Gear on Worm 72, 1st on Stud 44, 2nd on Stud 64, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
11.400-20	11.406	69½	20½	11.419	61¾	28¼	11.408	56	34							11.410	43¾	46¼						
11.420-40	11.424	69¾	20¼							11.432	51¼	38¾	11.423	47¼	42¾				11.421	40¼	49¾	11.426	37½	52½
11.440-60	11.443	70	20	11.446	62	28	11.441	56¼	33¾															
11.460-80	11.479	70½	19½	11.472	62¼	27¾	11.475	56½	33½	11.472	51½	38½	11.469	47½	42½	11.462	44	46						
11.480-00	11.496	70¾	19¼	11.499	62½	27½													11.480	40½	49½	11.491	37¾	52¼
11.500-20	11.513	71	19				11.508	56¾	33¼	11.512	51¾	38¼	11.515	47¾	42¼	11.514	44¼	45¾						
11.520-40	11.530	71¼	18¾	11.525	62¾	27¼													11.539	40¾	49¼			
11.540-60	11.547	71½	18½	11.550	63	27	11.540	57	33	11.551	52	38										11.557	38	52
11.560-80	11.564	71¾	18¼	11.575	63¼	26¾	11.573	57¼	32¾				11.560	48	42	11.565	44½	45½						
11.580-00	11.580	72	18							11.591	52¼	37¾							11.597	41	49			
11.600-20	11.612	72½	17½	11.600	63½	26½	11.605	57½	32½				11.606	48¼	41¾	11.617	44¾	45¼						
11.620-40	11.629	72¾	17¼	11.625	63¾	26¼	11.637	57¾	32¼	11.630	52½	37½										11.620	38¼	51¾
11.640-60	11.644	73	17	11.650	64	26							11.650	48½	41½				11.656	41¼	48¾			
11.660-80	11.677	73½	16½	11.675	64¼	25¾	11.669	58	32	11.669	52¾	37¼				11.667	45	45						
11.680-00	11.690	73¾	16¼										11.695	48¾	41¼							11.685	38½	51½
11.700-20	11.704	74	16	11.700	64½	25½	11.700	58¼	31¾	11.707	53	37				11.718	45¼	44¾	11.713	41½	48½			
11.720-40	11.734	74½	15½	11.724	64¾	25¼	11.732	58½	31½															
11.740-60	11.748	74¾	15¼	11.748	65	25				11.745	53¼	36¾	11.740	49	41							11.749	38¾	51¼
11.760-80	11.761	75	15	11.772	65¼	24¾	11.763	58¾	31¼							11.769	45½	44½	11.771	41¾	48¼			
11.780-00	11.788	75½	14½	11.796	65½	24½	11.794	59	31	11.783	53½	36½	11.783	49¼	40¾									
11.800-20	11.815	76	14	11.819	65¾	24¼										11.819	45¾	44¼				11.813	39	51
11.820-40	11.828	76¼	13¾				11.825	59¼	30¾	11.821	53¾	36¼	11.828	49½	40½				11.829	42	48			
11.840-60	11.840	76½	13½	11.842	66	24	11.856	59½	30½															
11.860-80	11.864	77	13	11.864	66¼	23¾				11.860	54	36	11.872	49¾	40¼	11.870	46	44				11.876	39¼	50¾
11.880-00	11.888	77½	12½	11.888	66½	23½	11.887	59¾	30¼	11.896	54¼	35¾							11.885	42¼	47¾			
11.900-20	11.900	77¾	12¼	11.910	66¾	23¼	11.917	60	30				11.917	50	40	11.919	46¼	43¾						
11.920-40	11.932	78½	11½	11.932	67	23				11.934	54½	35½												
11.940-60	11.953	79	11	11.955	67¼	22¾	11.946	60¼	29¾										11.942	42½	47½	11.940	39½	50½
11.960-80	11.973	79½	10½	11.977	67½	22½	11.975	60½	29½	11.971	54¾	35¼	11.960	50¼	39¾	11.969	46½	43½						
11.980-00	11.992	80	10	11.998	67¾	22¼													11.999	42¾	47¼			

LEADS FROM 12.000 TO

Approximate Lead	Gear on Worm 56, 1st on Stud 24, 2nd on Stud 40, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
12.000-20	12.019	68	22	12.006	60¾	29¼	12.008	55	35	12.003	50½	39½	12.019	46¾	43¼				12.003	39¾	50¼			
12.020-40				12.035	61	29																		
12.040-60	12.040	68¼	21¾				12.044	55¼	34¾	12.046	50¾	39¼				12.056	43	47						
12.060-80	12.061	68½	21½	12.064	61¼	28¾							12.068	47	43				12.066	40	50	12.065	37¼	52¾
12.080-00	12.082	68¾	21¼	12.093	61½	28½	12.080	55½	34½	12.090	51	39												
12.100-20	12.102	69	21				12.117	55¾	34¼				12.117	47¼	42¾	12.112	43¼	46¾						
12.120-40	12.122	69¼	20¾	12.121	61¾	28¼				12.132	51¼	38¾							12.128	40¼	49¾	12.134	37½	52½
12.140-60	12.142	69½	20½	12.150	62	28	12.152	56	34															
12.160-80	12.162	69¾	20¼	12.178	62¼	27¾				12.174	51½	38½	12.165	47½	42½	12.169	43½	46½						
12.180-00	12.181	70	20				12.189	56¼	33¾										12.190	40½	49½			
12.200-20	12.201	70¼	19¾	12.206	62½	27½				12.216	51¾	38¼	12.214	47¾	42¼							12.203	37¾	52¼
12.220-40	12.238	70¾	19¼	12.233	62¾	27¼	12.224	56½	33½							12.223	43¾	46¼						
12.240-60	12.256	71	19							12.258	52	38							12.252	40¾	49¼			
12.260-80	12.275	71¼	18¾	12.260	63	27	12.260	56¾	33¼				12.262	48	42							12.272	38	52
12.280-00	12.292	71½	18½	12.287	63¼	26¾	12.294	57	33							12.280	44	46						
12.300-20	12.310	71¾	18¼	12.314	63½	26½				12.300	52¼	37¾	12.310	48¼	41¾				12.315	41	49			
12.320-40	12.328	72	18				12.330	57¼	32¾							12.335	44¼	45¾						
12.340-60	12.346	72¼	17¾	12.341	63¾	26¼				12.341	52½	37½	12.358	48½	41½							12.340	38¼	51¾
12.360-80	12.362	72½	17½	12.366	64	26	12.363	57½	32½										12.376	41¼	48¾			
12.380-00	12.395	73	17	12.393	64¼	25¾	12.397	57¾	32¼	12.382	52¾	37¼				12.390	44½	45½						
12.400-20	12.412	73¼	16¾	12.419	64½	25½							12.406	48¾	41¼							12.409	38½	51½
12.420-40	12.428	73½	16½				12.430	58	32	12.422	53	37							12.439	41½	48½			
12.440-60	12.444	73¾	16¼	12.445	64¾	25¼										12.444	44¾	45¼						
12.460-80	12.460	74	16	12.470	65	25	12.464	58¼	31¾	12.463	53¼	36¾	12.453	49	41									
12.480-00	12.491	74½	15½	12.496	65¼	24¾	12.498	58½	31½													12.477	38¾	51¼
12.500-20	12.506	74¾	15¼							12.504	53½	36½	12.500	49¼	40¾	12.500	45	45	12.500	41¾	48¼			
12.520-40	12.521	75	15	12.520	65½	24½	12.531	58¾	31¼															
12.540-60	12.550	75½	14½	12.545	65¾	24¼				12.544	53¾	36¼	12.547	49½	40½	12.553	45¼	44¾				12.545	39	51
12.560-80	12.578	76	14	12.570	66	24	12.564	59	31										12.560	42	48			
12.580-00	12.591	76¼	13¾	12.594	66¼	23¾				12.585	54	36	12.593	49¾	40¼									

LEADS FROM 12.600 TO 13.200

Approximate Lead	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 100	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
12.600-20	12.619	66½	23½									
12,620-40				12.630	59½	30½	12.625	54¼	35¾			
12.640-60	12.643	66¾	23¼							12.640	50	40
12.660-80	12.666	67	23	12.662	59¾	30¼	12.664	54½	35½			
12.680-00	12.690	67¼	22¾	12.695	60	30				12.686	50¼	39¾
12.700-20	12.713	67½	22½				12.703	54¾	35¼			
12.720-40	12.736	67¾	22¼	12.726	60¼	29¾				12.732	50½	39½
12.740-60	12.758	68	22	12.758	60½	29½	12.742	55	35			
12.760-80										12.778	50¾	39¼
12.780-00	12.780	68¼	21¾	12.790	60¾	29¼	12.781	55¼	34¾			
12.800-20	12.802	68½	21½									
12.820-40	12.824	68¾	21¼	12.820	61	29	12.820	55½	34½	12.823	51	39
12.840-60	12.846	69	21	12.852	61¼	28¾	12.858	55¾	34¼			
12.860-80	12.868	69¼	20¾							12.868	51¼	38¾
12.880-00	12.889	69½	20½	12.882	61½	28½	12.896	56	34			
12.900-20	12.910	69¾	20¼	12.912	61¾	28¼				12.913	51½	38½
12.920-40	12.930	70	20				12.933	56¼	33¾			
12.940-60	12.950	70¼	19¾	12.943	62	28				12.958	51¾	38¼
12.960-80	12.971	70½	19½	12.973	62¼	27¾	12.972	56½	33½			
12.980-00	12.990	70¾	19¼									
13.000-20	13.010	71	19	13.002	62½	27½	13.010	56¾	33¼	13.003	52	38
13.020-40	13.030	71¼	18¾	13.032	62¾	27¼						
13.040-60	13.049	71½	18½				13.046	57	33	13.048	52¼	37¾
13.060-80	13.068	71¾	18¼	13.061	63	27						
13.080-00	13.086	72	18	13.090	63¼	26¾	13.083	57¼	32¾	13.090	52½	37½
13.100-20	13.104	72¼	17¾	13.118	63½	26½	13.119	57½	32½			
13.120-40	13.122	72½	17½							13.134	52¾	37¼
13.140-60	13.158	73	17	13.147	63¾	26¼	13.155	57¾	32¼			
13.160-80	13.175	73¼	16¾	13.174	64	26				13.177	53	37
13.180-00	13.192	73½	16½				13.190	58	32			

Approximate Lead	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
12.600-20	12.608	45½	44½				12.613	39¼	50¾			
12,620-40				12.621	42¼	47¾				12.633	36¾	53¼
12.640-60												
12.660-80	12.661	45¾	44¼									
12.680-00				12.681	42½	47½	12.680	39½	50½			
12.700-20	12.716	46	44							12.709	37	53
12.720-40												
12.740-60				12.741	42¾	47¼	12.747	39¾	50¼			
12.760-80	12.769	46¼	43¾									
12.780-00										12.782	37¼	52¾
12.800-20				12.802	43	47	12.813	40	50			
12.820-40	12.822	46½	43½									
12.840-60										12.854	37½	52½
12.860-80	12.875	46¾	43¼	12.861	43¼	46¾	12.879	40¼	49¾			
12.880-00												
12.900-20												
12.920-40	12.929	47	43	12.921	43½	46½				12.928	37¾	52¼
12.940-60							12.945	40½	49½			
12.960-80												
12.980-00	12.980	47¼	42¾	12.980	43¾	46¼						
13.000-20							13.011	40¾	49¼	13.000	38	52
13.020-40	13.033	47½	42½									
13.040-60				13.040	44	46						
13.060-80							13.078	41	49	13.073	38¼	51¾
13.080-00	13.085	47¾	42¼	13.098	44¼	45¾						
13.100-20												
13.120-40	13.137	48	42									
13.140-60				13.157	44½	45½	13.143	41¼	48¾	13.145	38½	51½
13.160-80												
13.180-00	13.188	48¼	41¾									

LEADS FROM 13.200 TO 13.800

Approximate Lead	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
13.200-20	13.202	64¼	25¾										13.215	44¾	45¼	13.209	41½	48½	13.217	38¾	51¼			
13.220-40	13.230	64½	25½	13.227	58¼	31¾	13.220	53¼	36¾	13.239	48½	41½										13.225	36	54
13.240-60	13.258	64¾	25¼																					
13.260-80				13.262	58½	31½	13.263	53½	36½				13.273	45	45	13.274	41¾	48¼						
13.280-00	13.285	65	25	13.298	58¾	31¼				13.290	48¾	41¼							13.289	39	51			
13.300-20	13.311	65¼	24¾				13.306	53¾	36¼													13.304	36¼	53¾
13.320-40	13.339	65½	24½	13.333	59	31							13.330	45¼	44¾									
13.340-60							13.349	54	36	13.340	49	41				13.340	42	48						
13.360-80	13.364	65¾	24¼	13.368	59¼	30¾													13.360	39¼	50¾			
13.380-00	13.390	66	24				13.392	54¼	35¾	13.391	49¼	40¾	13.388	45½	44½							13.384	36½	53½
13.400-20	13.417	66¼	23¾	13.403	59½	30½										13.403	42¼	47¾						
13.420-40				13.438	59¾	30¼	13.433	54½	35½										13.432	39½	50½			
13.440-60	13.442	66½	23½							13.441	49½	40½	13.445	45¾	44¼									
13.460-80	13.467	66¾	23¼	13.471	60	30	13.475	54¾	35¼							13.467	42½	47½				13.462	36¾	53¼
13.480-00	13.493	67	23							13.491	49¾	40¼												
13.500-20	13.519	67¼	22¾	13.505	60¼	29¾	13.517	55	35				13.502	46	44				13.503	39¾	50¼			
13.520-40				13.538	60½	29½										13.530	42¾	47¼						
13.540-60	13.543	67½	22½				13.558	55¼	34¾	13.541	50	40										13.541	37	53
13.560-80	13.568	67¾	22¼	13.572	60¾	29¼							13.560	46¼	43¾				13.573	40	50			
13.580-00	13.590	68	22				13.599	55½	34½	13.590	50¼	39¾				13.595	43	47						
13.600-20	13.615	68¼	21¾	13.605	61	29							13.616	46½	43½							13.618	37¼	52¾
13.620-40	13.639	68½	21½	13.638	61¼	28¾																		
13.640-60							13.640	55¾	34¼	13.640	50½	39½				13.659	43¼	46¾	13.643	40¼	49¾			
13.660-80	13.662	68¾	21¼	13.670	61½	28½							13.672	46¾	43¼									
13.680-00	13.685	69	21				13.680	56	34	13.689	50¾	39¼										13.696	37½	52½
13.700-20	13.709	69¼	20¾	13.702	61¾	28¼													13.714	40½	49½			
13.720-40	13.730	69½	20½	13.735	62	28	13.720	56¼	33¾	13.738	51	39	13.728	47	43	13.722	43½	46½						
13.740-60	13.752	69¾	20¼																					
13.760-80	13.775	70	20	13.767	62¼	27¾	13.760	56½	33½													13.775	37¾	52¼
13.780-00	13.797	70¼	19¾	13.798	62½	27½				13.786	51¼	38¾	13.784	47¼	42¾	13.784	43¾	46¼	13.783	40¾	49¼			

LEADS FROM 13.800 TO 14.400

Approximate Lead	Gear on Worm 86, 1st on Stud 44, 2nd on Stud 48, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
13.800-20	13.818	70½	19½				13.800	56¾	33¼															
13.820-40	13.839	70¾	19¼	13.830	62¾	27¼	13.839	57	33	13.833	51½	38½												
13.840-60	13.859	71	19										13.840	47½	42½	13.847	44	46						
13.860-80				13.860	63	27	13.878	57¼	32¾										13.854	41	49	13.853	38	52
13.880-00	13.880	71¼	18¾	13.890	63¼	26¾	13.916	57½	32½	13.882	51¾	38¼	13.895	47¾	42¼									
13.900-20	13.900	71½	18½													13.909	44¼	45¾						
13.920-40	13.920	71¾	18¼	13.920	63½	26½				13.930	52	38							13.923	41¼	48¾	13.929	38¼	51¾
13.940-60	13.940	72	18	13.950	63¾	26¼	13.954	57¾	32¼				13.950	48	42									
13.960-80	13.960	72¼	17¾							13.978	52¼	37¾				13.971	44½	45½						
13.980-00	13.998	72¾	17¼	13.980	64	26	13.992	58	32										13.992	41½	48½			
14.000-20	14.017	73	17	14.010	64¼	25¾							14.004	48¼	41¾							14.007	38½	51½
14.020-40	14.035	73¼	16¾				14.030	58¼	31¾	14.024	52½	37½				14.033	44¾	45¼						
14.040-60	14.053	73½	16½	14.040	64½	25½							14.058	48½	41½									
14.060-80	14.071	73¾	16¼	14.069	64¾	25¼	14.069	58½	31½	14.070	52¾	37¼							14.061	41¾	48¼			
14.080-00	14.090	74	16	14.098	65	25										14.095	45	45				14.083	38¾	51¼
14.100-20	14.108	74¼	15¾				14.106	58¾	31¼	14.118	53	37	14.113	48¾	41¼									
14.120-40	14.125	74½	15½	14.127	65¼	24¾													14.129	42	48			
14.140-60	14.159	75	15	14.155	65½	24½	14.143	59	31							14.157	45¼	44¾						
14.160-80	14.175	75¼	14¾							14.163	53¼	36¾	14.166	49	41							14.160	39	51
14.180-00	14.191	75½	14½	14.183	65¾	24¼	14.180	59¼	30¾										14.198	42¼	47¾			
14.200-20	14.207	75¾	14¼	14.211	66	24	14.217	59½	30½	14.210	53½	36½				14.218	45½	44½						
14.220-40	14.222	76	14	14.238	66¼	23¾							14.220	49¼	40¾							14.236	39¼	50¾
14.240-60	14.253	76½	13½				14.253	59¾	30¼	14.255	53¾	36¼												
14.260-80	14.268	76¾	13¼	14.265	66½	23½							14.272	49½	40½	14.279	45¾	44¼	14.266	42½	47½			
14.280-00	14.283	77	13	14.291	66¾	23¼	14.290	60	30															
14.300-20	14.310	77½	12½	14.318	67	23				14.300	54	36										14.313	39½	50½
14.320-40	14.338	78	12				14.325	60¼	29¾				14.326	49¾	40¼				14.333	42¾	47¼			
14.340-60	14.351	78¼	11¾	14.345	67¼	22¾				14.345	54¼	35¾				14.340	46	44						
14.360-80	14.364	78½	11½	14.371	67½	22½	14.360	60½	29½															
14.380-00	14.390	79	11	14.398	67¾	22¼				14.390	54½	35½	14.380	50	40							14.388	39¾	50¼

LEADS FROM 14.400 TO 15.000

Approximate Lead	Gear on Worm 64, 1st on Stud 32, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
14.400-20												
14.420-40	14.422	68	22	14.431	61	29	14.437	54¾	35¼	14.431	50¼	39¾
14.440-60	14.448	68¼	21¾									
14.460-80	14.473	68½	21½	14.466	61¼	28¾						
14.480-00	14.498	68¾	21¼				14.480	55	35	14.483	50½	39½
14.500-20				14.500	61½	28½						
14.520-40	14.522	69	21	14.534	61¾	28¼	14.525	55¼	34¾	14.536	50¾	39¼
14.540-60	14.547	69¼	20¾									
14.560-80	14.570	69½	20½	14.568	62	28	14.569	55½	34½			
14.580-00	14.594	69¾	20¼							14.588	51	39
14.600-20	14.618	70	20	14.602	62¼	27¾	14.611	55¾	34¼			
14.620-40				14.636	62½	27½						
14.640-60	14.640	70¼	19¾				14.654	56	34	14.640	51¼	38¾
14.660-80	14.663	70½	19½	14.670	62¾	27¼						
14.680-00	14.686	70¾	19¼				14.698	56¼	33¼	14.690	51½	38½
14.700-20	14.706	71	19	14.702	63	27						
14.720-40	14.730	71¼	18¾	14.733	63¼	26¾						
14.740-60	14.750	71½	18½				14.740	56½	33½	14.740	51¾	38¼
14.760-80	14.771	71¾	18¼	14.766	63½	26½						
14.780-00	14.793	72	18	14.790	63¾	26¼	14.783	56¾	33¼	14.792	52	38
14.800-20	14.814	72¼	17¾									
14.820-40	14.834	72½	17½	14.829	64	26	14.825	57	33			
14.840-60	14.854	72¾	17¼							14.842	52¼	37¾
14.860-80	14.874	73	17	14.861	64¼	25¾	14.868	57¼	32¾			
14.880-00	14.894	73¼	16¾	14.892	64½	25½				14.892	52½	37½
14.900-20	14.913	73½	16½				14.908	57½	32½			
14.920-40	14.932	73¾	16¼	14.923	64¾	25¼						
14.940-60	14.952	74	16	14.953	65	25	14.950	57¾	32¼	14.940	52¾	37¼
14.960-80	14.970	74¼	15¾									
14.980-00	14.990	74½	15½	14.984	65¼	24¾	14.990	58	32	14.990	53	37

Approximate Lead	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 40, 2nd on Stud 72, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
14.400-20	14.400	46¼	43¾	14.401	43	47						
14.420-40												
14.440-60										14.444	37	53
14.460-80	14.460	46½	43½	14.469	43¼	46¾	14.462	40	50			
14.480-00												
14.500-20	14.519	46¾	43¼									
14.520-40				14.536	43½	46½	14.538	40¼	49¾	14.526	37¼	52¾
14.540-60												
14.560-80	14.579	47	43									
14.580-00												
14.600-20				14.602	43¾	46¼	14.612	40½	49½	14.610	37½	52½
14.620-40	14.638	47¼	42¾									
14.640-60												
14.660-80				14.669	44	46						
14.680-00	14.697	47½	42½				14.687	40¾	49¼	14.693	37¾	52¼
14.700-20												
14.720-40				14.734	44¼	45¾						
14.740-60	14.755	47¾	42¼									
14.760-80							14.761	41	49	14.775	38	52
14.780-00												
14.800-20	14.813	48	42	14.800	44½	45½						
14.820-40							14.835	41¼	48¾			
14.840-60										14.858	38¼	51¾
14.860-80	14.872	48¼	41¾	14.867	44¾	45¼						
14.880-00												
14.900-20							14.910	41½	48½			
14.920-40	14.930	48½	41½	14.931	45	45						
14.940-60										14.940	38½	51½
14.960-80												
14.980-00	14.988	48¾	41¼	14.996	45¼	44¾	14.983	41¾	48¼			

LEADS FROM 15.000 TO 16.200

Approximate Lead	Gear on Worm 72, 1st on Stud 40, 2nd on Stud 44, Gear on Screw 40	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
15.000-40	15.014	65½	24½	15.030	58¼	31¾						
15.040-80	15.073	66	24	15.071	58½	31½	15.040	53¼	36¾	15.043	49	41
15.080-20	15.101	66¼	23¾	15.111	58¾	31¼	15.089	53½	36½	15.100	49¼	40¾
15.120-60	15.131	66½	23½	15.151	59	31	15.138	53¾	36¼	15.158	49½	40½
15.160-00	15.160	66¾	23¼	15.191	59¼	30¾	15.186	54	36			
15.200-40	15.217	67¼	22¾	15.230	59½	30½	15.233	54¼	35¾	15.213	49¾	40¼
15.240-80	15.244	67½	22½	15.270	59¾	30¼				15.270	50	40
15.280-20	15.299	68	22	15.309	60	30	15.281	54½	35½			
15.320-60	15.352	68½	21½	15.347	60¼	29¾	15.329	54¾	35¼	15.325	50¼	39¾
15.360-00	15.379	68¾	21¼	15.385	60½	29½	15.376	55	35	15.381	50½	39½
15.400-40	15.404	69	21	15.422	60¾	29¼	15.423	55¼	34¾	15.426	50¾	39¼
15.440-80	15.455	69½	20½	15.460	61	29	15.470	55½	34½			
15.480-20	15.505	70	20	15.498	61¼	28¾	15.515	55¾	34¼	15.491	51	39
15.520-60	15.554	70½	19½	15.535	61½	28½				15.546	51¼	38¾
15.560-00	15.577	70¾	19¼	15.572	61¾	28¼	15.561	56	34			
15.600-40	15.624	71¼	18¾	15.609	62	28	15.607	56¼	33¾	15.600	51½	38½
15.640-80	15.647	71½	18½	15.643	62¼	27¾	15.653	56½	33½	15.653	51¾	38¼
15.680-20	15.714	72¼	17¾	15.680	62½	27½	15.693	56¾	33¼	15.709	52	38
15.720-60	15.735	72½	17½	15.750	63	27	15.742	57	33			
15.760-00	15.798	73¼	16¾	15.783	63¼	26¾	15.788	57¼	32¾	15.761	52¼	37¾
15.800-40	15.819	73½	16½	15.819	63½	26½	15.830	57½	32½	15.814	52½	37½
15.840-80	15.860	74	16	15.853	63¾	26¼	15.874	57¾	32¼	15.868	52¾	37¼
15.880-20	15.900	74½	15½	15.887	64	26	15.918	58	32	15.919	53	37
15.920-60	15.938	75	15	15.954	64½	25½						
15.960-00	15.973	75½	14½	15.988	64¾	25¼	15.960	58¼	31¾	15.971	53¼	36¾
16.000-40	16.010	76	14	16.020	65	25	16.004	58½	31½	16.023	53½	36½
16.040-80	16.043	76½	13½	16.053	65¼	24¾	16.047	58¾	31¼	16.075	53¾	36¼
16.080-20	16.109	77½	12½	16.085	65½	24½	16.089	59	31			
16.120-60	16.140	78	12	16.148	66	24	16.131	59¼	30¾	16.127	54	36
16.160-00	16.197	79	11	16.180	66¼	23¾	16.173	59½	30½	16.177	54¼	35¾

Approximate Lead	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 40, 2nd on Stud 72, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 64, 2nd on Stud 72, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
15.000-40							15.022	38¾	51¼	15.028	36	54
15.040-80	15.060	45½	44½	15.055	42	48						
15.080-20							15.105	39	51	15.118	36¼	53¾
15.120-60	15.125	45¾	44¼	15.128	42¼	47¾						
15.160-00	15.190	46	44				15.185	39¼	50¾			
15.200-40				15.200	42½	47½				15.208	36½	53½
15.240-80	15.253	46¼	43¾	15.272	42¾	47¼	15.268	39½	50½			
15.280-20	15.317	46½	43½							15.298	36¾	53¼
15.320-60				15.345	43	47	15.347	39¾	50¼			
15.360-00	15.380	46¾	43¼							15.388	37	53
15.400-40				15.417	43¼	46¾	15.427	40	50			
15.440-80	15.443	47	43							15.476	37¼	52¾
15.480-20	15.507	47¼	42¾	15.489	43½	46½	15.507	40¼	49¾			
15.520-60				15.559	43¾	46¼						
15.560-00	15.569	47½	42½				15.587	40½	49½	15.564	37½	52½
15.600-40	15.630	47¾	42¼	15.630	44	46						
15.640-80							15.667	40¾	49¼	15.653	37¾	52¼
15.680-20	15.692	48	42	15.700	44¼	45¾						
15.720-60	15.754	48¼	41¾				15.745	41	49	15.741	38	52
15.760-00				15.770	44½	45½						
15.800-40	15.815	48½	41½				15.824	41¼	48¾	15.829	38¼	51¾
15.840-80	15.876	48¾	41¼	15.840	44¾	45¼						
15.880-20				15.910	45	45	15.903	41½	48½	15.916	38½	51½
15.920-60	15.936	49	41									
15.960-00	15.996	49¼	40¾	15.980	45¼	44¾	15.981	41¾	48¼			
16.000-40										16.002	38¾	51¼
16.040-80	16.057	49½	40½	16.048	45½	44½	16.060	42	48			
16.080-20	16.116	49¾	40¼	16.117	45¾	44¼				16.090	39	51
16.120-60							16.137	42¼	47¾			
16.160-00	16.176	50	40	16.185	46	44				16.177	39¼	50¾

LEADS FROM 16.200 TO 17.400

Approximate Lead	Gear on Worm 100, 1st on Stud 44, 2nd on Stud 56, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 40, 2nd on Stud 72, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 64, 2nd on Stud 72, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 72, 2nd on Stud 86, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
16.200–40	16.210	66½	23½	16.214	59¾	30¼	16.228	54½	35½	16.235	50¼	39¾				16.213	42½	47½						
16.240–80	16.271	67	23	16.256	60	30	16.279	54¾	35¼				16.253	46¼	43¾				16.263	39½	50½	16.242	36¾	53¼
16.280–20	16.301	67¼	22¾	16.296	60¼	29¾				16.294	50½	39½				16.290	42¾	47¼						
16.320–60	16.331	67½	22½	16.337	60½	29½	16.329	55	35	16.352	50¾	39¼	16.321	46½	43½				16.349	39¾	50¾	16.337	37	53
16.360–00	16.389	68	22	16.378	60¾	29¼	16.379	55¼	34¾				16.389	46¾	43¼	16.368	43	47						
16.400–40	16.419	68¼	21¾	16.417	61	29	16.429	55½	34½	16.410	51	39							16.434	40	50	16.432	37¼	52¾
16.440–80	16.447	68½	21½	16.457	61¼	28¾	16.477	55¾	34¼	16.468	51¼	38¾	16.455	47	43	16.445	43¼	46¾						
16.480–20	16.502	69	21	16.497	61½	28½																		
16.520–60	16.558	69½	20½	16.535	61¾	28¼	16.526	56	34	16.525	51½	38½	16.522	47¼	42¾	16.520	43½	46½	16.520	40¼	49¾	16.525	37½	52½
16.560–00	16.584	69¾	20¼	16.574	62	28	16.574	56¼	33¾	16.582	51¾	38¼	16.589	47½	42½	16.596	43¾	46¼						
16.600–40	16.610	70	20	16.612	62¼	27¾	16.622	56½	33½										16.604	40½	49½	16.620	37¾	52¼
16.640–80	16.663	70½	19½	16.650	62½	27½	16.670	56¾	33¼	16.640	52	38	16.655	47¾	42¼	16.671	44	46						
16.680–20	16.711	71	19	16.688	62¾	27¼	16.718	57	33	16.698	52¼	37¾							16.689	40¾	49¼	16.713	38	52
16.720–60	16.738	71¼	18¾	16.725	63	27				16.752	52½	37½	16.720	48	42	16.748	44¼	45¾						
16.760–00	16.762	71½	18½	16.798	63½	26½	16.766	57¼	32¾				16.787	48¼	41¾				16.773	41	49			
16.800–40	16.810	72	18	16.835	63¾	26¼	16.811	57½	32½	16.808	52¾	37¼				16.822	44½	45½				16.805	38¼	51¾
16.840–80	16.858	72½	17½	16.870	64	26	16.858	57¾	32¼	16.863	53	37	16.851	48½	41½				16.858	41¼	48¾			
16.880–20	16.881	72¾	17¼	16.906	64¼	25¾	16.904	58	32	16.919	53¼	36¾	16.918	48¾	41¼	16.898	44¾	45¼				16.900	38½	51½
16.920–60	16.925	73¼	16¾	16.941	64½	25½	16.950	58¼	31¾										16.942	41½	48½			
16.960–00	16.991	74	16	16.977	64¾	25¼	16.996	58½	31½	16.974	53½	36½	16.980	49	41	16.971	45	45				16.990	38¾	51¼
17.000–40	17.033	74½	15½	17.011	65	25				17.030	53¾	36¼							17.025	41¾	48¼			
17.040–80	17.074	75	15	17.047	65¼	24¾	17.040	58¾	31¼				17.045	49¼	40¾	17.045	45¼	44¾						
17.080–20	17.093	75¼	14¾	17.080	65½	24½	17.086	59	31	17.083	54	36	17.110	49½	40½	17.119	45½	44½	17.109	42	48	17.084	39	51
17.120–60	17.151	76	14	17.148	66	24	17.130	59¼	30¾	17.137	54¼	35¾												
17.160–00	17.188	76½	13½	17.180	66¼	23¾	17.175	59½	30½	17.190	54½	35½	17.172	49¾	40¼	17.191	45¾	44¼	17.190	42¼	47¾	17.175	39¼	50¾
17.200–40	17.206	76¾	13¼	17.214	66½	23½	17.220	59¾	30¼				17.236	50	40									
17.240–80	17.258	77½	12½	17.278	67	23	17.263	60	30	17.244	54¾	35¼				17.264	46	44	17.272	42½	47½	17.269	39½	50½
17.280–20	17.290	78	12	17.310	67¼	22¾	17.306	60¼	29¾	17.298	55	35	17.300	50¼	39¾									
17.320–60	17.321	78½	11½	17.341	67½	22½	17.349	60½	29½	17.350	55¼	34¾				17.337	46¼	43¾	17.354	42¾	47¼	17.359	39¾	50¼
17.360–00	17.380	79½	10½	17.373	67¾	22¼	17.392	60¾	29¼				17.361	50½	39½									

LEADS FROM 17.400 TO 18.600

Approximate Lead	Gear on Worm 86, 1st on Stud 28, 2nd on Stud 44, Gear on Screw 72	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 28, 2nd on Stud 48, Gear on Screw 86	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 40, 2nd on Stud 72, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 64, 2nd on Stud 72, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 72, 2nd on Stud 86, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
17.400-40	17.403	68	22	17.434	61	29	17.403	55½	34½	17.423	50¾	39¼	17.410	46½	43½	17.437	43	47						
17.440-80	17.464	68½	21½	17.476	61¼	28¾	17.454	55¾	34¼										17.449	40	50	17.450	37½	52½
17.480-20	17.494	68¾	21¼	17.518	61½	28½	17.506	56	34	17.486	51	39	17.480	46¾	43¼	17.518	43¼	46¾						
17.520-60	17.524	69	21	17.559	61¾	28¼	17.558	56¼	33¾	17.547	51¼	38¾	17.552	47	43				17.539	40¼	49¾	17.550	37¾	52¼
17.560-00	17.581	69½	20½																					
17.600-40	17.639	70	20	17.600	62	28	17.609	56½	33½	17.609	51½	38½	17.624	47¼	42¾	17.600	43½	46½	17.630	40½	49½			
17.640-80	17.666	70¼	19¾	17.641	62¼	27¾	17.660	56¾	33¼	17.670	51¾	38¼										17.649	38	52
17.680-20	17.694	70½	19½	17.681	62½	27½	17.710	57	33				17.695	47½	42½	17.680	43¾	46¼						
17.720-60	17.746	71	19	17.721	62¾	27¼				17.730	52	38							17.720	40¾	49¼	17.746	38¼	51¾
17.760-00	17.774	71¼	18¾	17.761	63	27	17.760	57¼	32¾	17.791	52¼	37¾	17.766	47¾	42¼	17.760	44	46						
17.800-40	17.800	71½	18½	17.839	63½	26½	17.809	57½	32½				17.836	48	42				17.810	41	49			
17.840-80	17.851	72	18	17.878	63¾	26¼	17.858	57¾	32¼	17.850	52½	37½				17.840	44¼	45¾				17.845	38½	51½
17.880-20	17.900	72½	17½	17.915	64	26	17.908	58	32	17.910	52¾	37¼	17.907	48¼	41¾				17.899	41¼	48¾			
17.920-60	17.950	73	17	17.953	64¼	25¾	17.955	58¼	31¾							17.920	44½	45½				17.942	38¾	51¼
17.960-00	17.997	73½	16½	17.991	64½	25½				17.970	53	37	17.975	48½	41½				17.989	41½	48½			
18.000-40	18.020	73¾	16¼	18.029	64¾	25¼	18.004	58½	31½	18.029	53¼	36¾				18.000	44¾	45¼						
18.040-80	18.043	74	16	18.065	65	25	18.051	58¾	31¼				18.045	48¾	41¼				18.077	41¾	48¼	18.040	39	51
18.080-20	18.088	74½	15½	18.102	65¼	24¾	18.100	59	31	18.088	53½	36½	18.113	49	41	18.080	45	45						
18.120-60	18.130	75	15	18.139	65½	24½	18.147	59¼	30¾	18.146	53¾	36¼				18.158	45¼	44¾				18.137	39¼	50¾
18.160-00	18.171	75½	14½	18.174	65¾	24¼	18.194	59½	30½				18.181	49¼	40¾				18.163	42	48			
18.200-40	18.211	76	14	18.210	66	24				18.203	54	36				18.236	45½	44½				18.235	39½	50½
18.240-80	18.270	76¾	13¼	18.245	66¼	23¾	18.240	59¾	30¼	18.260	54¼	35¾	18.250	49½	40½				18.252	42¼	47¾			
18.280-20	18.308	77¼	12¾	18.280	66½	23½	18.288	60	30	18.319	54½	35½	18.318	49¾	40¼	18.313	45¾	44¼						
18.320-60	18.326	77½	12½	18.349	67	23	18.332	60¼	29¾										18.340	42½	47½	18.330	39¾	50¼
18.360-00	18.360	78	12	18.382	67¼	22¾	18.379	60½	29½	18.375	54¾	35¼	18.385	50	40	18.390	46	44						
18.400-40	18.410	78¾	11¼	18.416	67½	22½	18.423	60¾	29¼	18.431	55	35							18.427	42¾	47¼	18.426	40	50
18.440-80	18.440	79¼	10¾	18.450	67¾	22¼	18.469	61	29				18.452	50¼	39¾	18.470	46¼	43¾						
18.480-20	18.486	80	10	18.482	68	22	18.513	61¼	28¾	18.488	55¼	34¾							18.513	43	47			
18.520-60				18.546	68¼	21¾	18.558	61½	28½	18.543	55½	34½	18.520	50½	39½	18.545	46½	43½				18.520	40¼	49¾
18.560-00				18.579	68½	21½				18.598	55¾	34¼	18.585	50¾	39¼									

LEADS FROM 18.600 TO 20.100

Approximate Lead	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 44, Gear on Screw 58	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 28, 2nd on Stud 56, Gear on Screw 64	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 64, 1st on Stud 40, 2nd on Stud 72, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 64, 2nd on Stud 72, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 100, 1st on Stud 72, 2nd on Stud 86, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 40, 2nd on Stud 64, Gear on Screw 48	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 86, 1st on Stud 32, 2nd on Stud 64, Gear on Screw 56	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)	Gear on Worm 72, 1st on Stud 32, 2nd on Stud 64, Gear on Screw 44	Angle to Set Spiral Head (Degrees)	Angle to Set Vertical Att. (Degrees)
18.600-50	18.645	62	28							18.622	46¾	43¼	18.600	43¼	46¾	18.617	40½	49½						
18.650-00	18.688	62¼	27¾	18.653	56	34	18.651	51	39				18.686	43½	46½				18.697	37½	52½	18.655	34¾	55¼
18.700-50	18.730	62½	27½	18.709	56¼	33¾	18.718	51¼	38¾	18.700	47	43				18.711	40¾	49¼						
18.750-00	18.773	62¾	27¼	18.763	56½	33½	18.782	51½	38½	18.775	47¼	42¾	18.770	43¾	46¼							18.772	35	55
18.800-50	18.815	63	27	18.817	56¾	33¼	18.849	51¾	38¼							18.806	41	49	18.803	37¾	52¼			
18.850-00	18.897	63½	26½	18.870	57	33				18.850	47½	42½	18.858	44	46							18.889	35¼	54¾
18.900-50	18.938	63¾	26¼	18.924	57¼	32¾	18.913	52	38	18.925	47¾	42¼	18.942	44¼	45¾	18.900	41¼	48¾	18.909	38	52			
18.950-00	18.978	64	26	18.977	57½	32½	18.979	52¼	37¾							18.996	41½	48½						
19.000-50	19.019	64¼	25¾	19.029	57¾	32¼	19.040	52½	37½	19.000	48	42	19.028	44½	45½				19.013	38¼	51¾	19.005	35½	54½
19.050-00	19.059	64½	25½	19.081	58	32				19.076	48¼	41¾				19.089	41¾	48¼						
19.100-50	19.138	65	25	19.132	58¼	31¾	19.104	52¾	37¼				19.111	44¾	45¼				19.120	38½	51½	19.121	35¾	54¼
19.150-00	19.177	65¼	24¾	19.184	58½	31½	19.168	53	37	19.150	48½	41½	19.196	45	45	19.180	42	48						
19.200-50	19.214	65½	24½	19.235	58¾	31¼	19.230	53¼	36¾	19.222	48¾	41¼							19.223	38¾	51¼	19.237	36	54
19.250-00	19.252	65¾	24¼	19.285	59	31	19.293	53½	36½	19.296	49	41	19.279	45¼	44¾	19.272	42¼	47¾						
19.300-50	19.328	66¼	24	19.337	59¼	30¾													19.329	39	51			
19.350-00	19.365	66½	23½	19.387	59½	30½	19.356	53¾	36¼	19.370	49¼	40¾	19.362	45½	44½	19.366	42½	47½				19.352	36¼	53¾
19.400-50	19.400	66¾	23¼	19.437	59¾	30¼	19.417	54	36	19.441	49½	40½	19.444	45¾	44¼				19.431	39¼	50¾			
19.450-00	19.473	67¼	22¾	19.485	60	30	19.478	54¼	35¾							19.458	42¾	47¼				19.468	36½	53½
19.500-50	19.509	67½	22½	19.535	60¼	29¾	19.540	54½	35½	19.513	49¾	40¼	19.528	46	44				19.537	39½	50½			
19.550-00	19.578	68	22	19.582	60½	29½				19.586	50	40				19.550	43	47				19.580	36¾	53¼
19.600-50	19.647	68½	21½	19.631	60¾	29¼	19.600	54¾	35¼				19.610	46¼	43¾	19.641	43¼	46¾	19.640	39¾	50¼			
19.650-00	19.680	68¾	21¼	19.680	61	29	19.660	55	35	19.658	50¼	39¾	19.690	46½	43½							19.695	37	53
19.700-50	19.714	69	21	19.728	61¼	28¾	19.720	55¼	34¾	19.729	50½	39½				19.732	43½	46½	19.741	40	50			
19.750-00	19.779	69½	20½	19.774	61½	28½	19.780	55½	34½				19.771	46¾	43¼									
19.800-50	19.842	70	20	19.820	61¾	28¼	19.839	55¾	34¼	19.800	50¾	39¼				19.822	43¾	46¼	19.843	40¼	49¾	19.808	37¼	52¾
19.850-00	19.873	70¼	19¾	19.866	62	28	19.898	56	34	19.870	51	39	19.853	47	43									
19.900-50	19.905	70½	19½	19.912	62¼	27¾				19.940	51¼	38¾	19.934	47¼	42¾	19.914	44	46	19.945	40½	49½	19.922	37½	52½
19.950-00	19.964	71	19	19.959	62½	27½	19.956	56¼	33¾															
20.000-50	20.025	71½	18½	20.003	62¾	27¼	20.013	56½	33½	20.010	51½	38½	20.014	47½	42½	20.003	44¼	45¾	20.049	40¾	49¼	20.035	37¾	52¼
20.050-00	20.054	71¾	18¼	20.092	63¼	26¾	20.071	56¾	33¼	20.079	51¾	38¼	20.094	47¾	42¼	20.092	44½	45½						

NATURAL SINES AND COSINES *

′	0° Sine	0° Cosine	1° Sine	1° Cosine	2° Sine	2° Cosine	3° Sine	3° Cosine	4° Sine	4° Cosine	′
0	.00000	1.	.01745	.99985	.03490	.99939	.05234	.99863	.06976	.99756	60
1	.00029	1.	.01774	.99984	.03519	.99938	.05263	.99861	.07005	.99754	59
2	.00058	1.	.01803	.99984	.03548	.99937	.05292	.99860	.07034	.99752	58
3	.00087	1.	.01832	.99983	.03577	.99936	.05321	.99858	.07063	.99750	57
4	.00116	1.	.01862	.99983	.03606	.99935	.05350	.99857	.07092	.99748	56
5	.00145	1.	.01891	.99982	.03635	.99934	.05379	.99855	.07121	.99746	55
6	.00175	1.	.01920	.99982	.03664	.99933	.05408	.99854	.07150	.99744	54
7	.00204	1.	.01949	.99981	.03693	.99932	.05437	.99852	.07179	.99742	53
8	.00233	1.	.01978	.99980	.03723	.99931	.05466	.99851	.07208	.99740	52
9	.00262	1.	.02007	.99980	.03752	.99930	.05495	.99849	.07237	.99738	51
10	.00291	1.	.02036	.99979	.03781	.99929	.05524	.99847	.07266	.99736	50
11	.00320	.99999	.02065	.99979	.03810	.99927	.05553	.99846	.07295	.99734	49
12	.00349	.99999	.02094	.99978	.03839	.99926	.05582	.99844	.07324	.99731	48
13	.00378	.99999	.02123	.99977	.03868	.99925	.05611	.99842	.07353	.99729	47
14	.00407	.99999	.02152	.99977	.03897	.99924	.05640	.99841	.07382	.99727	46
15	.00436	.99999	.02181	.99976	.03926	.99923	.05669	.99839	.07411	.99725	45
16	.00465	.99999	.02211	.99976	.03955	.99922	.05698	.99838	.07440	.99723	44
17	.00495	.99999	.02240	.99975	.03984	.99921	.05727	.99836	.07469	.99721	43
18	.00524	.99999	.02269	.99974	.04013	.99919	.05756	.99834	.07498	.99719	42
19	.00553	.99998	.02298	.99974	.04042	.99918	.05785	.99833	.07527	.99716	41
20	.00582	.99998	.02327	.99973	.04071	.99917	.05814	.99831	.07556	.99714	40
21	.00611	.99998	.02356	.99972	.04100	.99916	.05844	.99829	.07585	.99712	39
22	.00640	.99998	.02385	.99972	.04129	.99915	.05873	.99827	.07614	.99710	38
23	.00669	.99998	.02414	.99971	.04159	.99913	.05902	.99826	.07643	.99708	37
24	.00698	.99998	.02443	.99970	.04188	.99912	.05931	.99824	.07672	.99705	36
25	.00727	.99997	.02472	.99969	.04217	.99911	.05960	.99822	.07701	.99703	35
26	.00756	.99997	.02501	.99969	.04246	.99910	.05989	.99821	.07730	.99701	34
27	.00785	.99997	.02530	.99968	.04275	.99909	.06018	.99819	.07759	.99699	33
28	.00814	.99997	.02560	.99967	.04304	.99907	.06047	.99817	.07788	.99696	32
29	.00844	.99996	.02589	.99966	.04333	.99906	.06076	.99815	.07817	.99694	31
30	.00873	.99996	.02618	.99966	.04362	.99905	.06105	.99813	.07846	.99692	30
31	.00902	.99996	.02647	.99965	.04391	.99904	.06134	.99812	.07875	.99689	29
32	.00931	.99996	.02676	.99964	.04420	.99902	.06163	.99810	.07904	.99687	28
33	.00960	.99995	.02705	.99963	.04449	.99901	.06192	.99808	.07933	.99685	27
34	.00989	.99995	.02734	.99963	.04478	.99900	.06221	.99806	.07962	.99683	26
35	.01018	.99995	.02763	.99962	.04507	.99898	.06250	.99804	.07991	.99680	25
36	.01047	.99995	.02792	.99961	.04536	.99897	.06279	.99803	.08020	.99678	24
37	.01076	.99994	.02821	.99960	.04565	.99896	.06308	.99801	.08049	.99676	23
38	.01105	.99994	.02850	.99959	.04594	.99894	.06337	.99799	.08078	.99673	22
39	.01134	.99994	.02879	.99959	.04623	.99893	.06366	.99797	.08107	.99671	21
40	.01164	.99993	.02908	.99958	.04653	.99892	.06395	.99795	.08136	.99668	20
41	.01193	.99993	.02938	.99957	.04682	.99890	.06424	.99793	.08165	.99666	19
42	.01222	.99993	.02967	.99956	.04711	.99889	.06453	.99792	.08194	.99664	18
43	.01251	.99992	.02996	.99955	.04740	.99888	.06482	.99790	.08223	.99661	17
44	.01280	.99992	.03025	.99954	.04769	.99886	.06511	.99788	.08252	.99659	16
45	.01309	.99991	.03054	.99953	.04798	.99885	.06540	.99786	.08281	.99657	15
46	.01338	.99991	.03083	.99952	.04827	.99883	.06569	.99784	.08310	.99654	14
47	.01367	.99991	.03112	.99952	.04856	.99882	.06598	.99782	.08339	.99652	13
48	.01396	.99990	.03141	.99951	.04885	.99881	.06627	.99780	.08368	.99649	12
49	.01425	.99990	.03170	.99950	.04914	.99879	.06656	.99778	.08397	.99647	11
50	.01454	.99989	.03199	.99949	.04943	.99878	.06685	.99776	.08426	.99644	10
51	.01483	.99989	.03228	.99948	.04972	.99876	.06714	.99774	.08455	.99642	9
52	.01513	.99989	.03257	.99947	.05001	.99875	.06743	.99772	.08484	.99639	8
53	.01542	.99988	.03286	.99946	.05030	.99873	.06773	.99770	.08513	.99637	7
54	.01571	.99988	.03316	.99945	.05059	.99872	.06802	.99768	.08542	.99635	6
55	.01600	.99987	.03345	.99944	.05088	.99870	.06831	.99766	.08571	.99632	5
56	.01629	.99987	.03374	.99943	.05117	.99869	.06860	.99764	.08600	.99630	4
57	.01658	.99986	.03403	.99942	.05146	.99867	.06889	.99762	.08629	.99627	3
58	.01687	.99986	.03432	.99941	.05175	.99866	.06918	.99760	.08658	.99625	2
59	.01716	.99985	.03461	.99940	.05205	.99864	.06947	.99758	.08687	.99622	1
60	.01745	.99985	.03490	.99939	.05234	.99863	.06976	.99756	.08716	.99619	0
′	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	′
	89°		88°		87°		86°		85°		

* Courtesy of The International Correspondence Schools.

NATURAL SINES AND COSINES

′	5°		6°		7°		8°		9°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.08716	.99619	.10453	.99452	.12187	.99255	.13917	.99027	.15643	.98769	60
1	.08745	.99617	.10482	.99449	.12216	.99251	.13946	.99023	.15672	.98764	59
2	.08774	.99614	.10511	.99446	.12245	.99248	.13975	.99019	.15701	.98760	58
3	.08803	.99612	.10540	.99443	.12274	.99244	.14004	.99015	.15730	.98755	57
4	.08831	.99609	.10569	.99440	.12302	.99240	.14033	.99011	.15758	.98751	56
5	.08860	.99607	.10597	.99437	.12331	.99237	.14061	.99006	.15787	.98746	55
6	.08889	.99604	.10626	.99434	.12360	.99233	.14090	.99002	.15816	.98741	54
7	.08918	.99602	.10655	.99431	.12389	.99230	.14119	.98998	.15845	.98737	53
8	.08947	.99599	.10684	.99428	.12418	.99226	.14148	.98994	.15873	.98732	52
9	.08976	.99596	.10713	.99424	.12447	.99222	.14177	.98990	.15902	.98728	51
10	.09005	.99594	.10742	.99421	.12476	.99219	.14205	.98986	.15931	.98723	50
11	.09034	.99591	.10771	.99418	.12504	.99215	.14234	.98982	.15959	.98718	49
12	.09063	.99588	.10800	.99415	.12533	.99211	.14263	.98978	.15988	.98714	48
13	.09092	.99586	.10829	.99412	.12562	.99208	.14292	.98973	.16017	.98709	47
14	.09121	.99583	.10858	.99409	.12591	.99204	.14320	.98969	.16046	.98704	46
15	.09150	.99580	.10887	.99406	.12620	.99200	.14349	.98965	.16074	.98700	45
16	.09179	.99578	.10916	.99402	.12649	.99197	.14378	.98961	.16103	.98695	44
17	.09208	.99575	.10945	.99399	.12678	.99193	.14407	.98957	.16132	.98690	43
18	.09237	.99572	.10973	.99396	.12706	.99189	.14436	.98953	.16160	.98686	42
19	.09266	.99570	.11002	.99393	.12735	.99186	.14464	.98948	.16189	.98681	41
20	.09295	.99567	.11031	.99390	.12764	.99182	.14493	.98944	.16218	.98676	40
21	.09324	.99564	.11060	.99386	.12793	.99178	.14522	.98940	.16246	.98671	39
22	.09353	.99562	.11089	.99383	.12822	.99175	.14551	.98936	.16275	.98667	38
23	.09382	.99559	.11118	.99380	.12851	.99171	.14580	.98931	.16304	.98662	37
24	.09411	.99556	.11147	.99377	.12880	.99167	.14608	.98927	.16333	.98657	36
25	.09440	.99553	.11176	.99374	.12908	.99163	.14637	.98923	.16361	.98652	35
26	.09469	.99551	.11205	.99370	.12937	.99160	.14666	.98919	.16390	.98648	34
27	.09498	.99548	.11234	.99367	.12966	.99156	.14695	.98914	.16419	.98643	33
28	.09527	.99545	.11263	.99364	.12995	.99152	.14723	.98910	.16447	.98638	32
29	.09556	.99542	.11291	.99360	.13024	.99148	.14752	.98906	.16476	.98633	31
30	.09585	.99540	.11320	.99357	.13053	.99144	.14781	.98902	.16505	.98629	30
31	.09614	.99537	.11349	.99354	.13081	.99141	.14810	.98897	.16533	.98624	29
32	.09642	.99534	.11378	.99351	.13110	.99137	.14838	.98893	.16562	.98619	28
33	.09671	.99531	.11407	.99347	.13139	.99133	.14867	.98889	.16591	.98614	27
34	.09700	.99528	.11436	.99344	.13168	.99129	.14896	.98884	.16620	.98609	26
35	.09729	.99526	.11465	.99341	.13197	.99125	.14925	.98880	.16648	.98604	25
36	.09758	.99523	.11494	.99337	.13226	.99122	.14954	.98876	.16677	.98600	24
37	.09787	.99520	.11523	.99334	.13254	.99118	.14982	.98871	.16706	.98595	23
38	.09816	.99517	.11552	.99331	.13283	.99114	.15011	.98867	.16734	.98590	22
39	.09845	.99514	.11580	.99327	.13312	.99110	.15040	.98863	.16763	.98585	21
40	.09874	.99511	.11609	.99324	.13341	.99106	.15069	.98858	.16792	.98580	20
41	.09903	.99508	.11638	.99320	.13370	.99102	.15097	.98854	.16820	.98575	19
42	.09932	.99506	.11667	.99317	.13399	.99098	.15126	.98849	.16849	.98570	18
43	.09961	.99503	.11696	.99314	.13427	.99094	.15155	.98845	.16878	.98565	17
44	.09990	.99500	.11725	.99310	.13456	.99091	.15184	.98841	.16906	.98561	16
45	.10019	.99497	.11754	.99307	.13485	.99087	.15212	.98836	.16935	.98556	15
46	.10048	.99494	.11783	.99303	.13514	.99083	.15241	.98832	.16964	.98551	14
47	.10077	.99491	.11812	.99300	.13543	.99079	.15270	.98827	.16992	.98546	13
48	.10106	.99488	.11840	.99297	.13572	.99075	.15299	.98823	.17021	.98541	12
49	.10135	.99485	.11869	.99293	.13600	.99071	.15327	.98818	.17050	.98536	11
50	.10164	.99482	.11898	.99290	.13629	.99067	.15356	.98814	.17078	.98531	10
51	.10192	.99479	.11927	.99286	.13658	.99063	.15385	.98809	.17107	.98526	9
52	.10221	.99476	.11956	.99283	.13687	.99059	.15414	.98805	.17136	.98521	8
53	.10250	.99473	.11985	.99279	.13716	.99055	.15442	.98800	.17164	.98516	7
54	.10279	.99470	.12014	.99276	.13744	.99051	.15471	.98796	.17193	.98511	6
55	.10308	.99467	.12043	.99272	.13773	.99047	.15500	.98791	.17222	.98506	5
56	.10337	.99464	.12071	.99269	.13802	.99043	.15529	.98787	.17250	.98501	4
57	.10366	.99461	.12100	.99265	.13831	.99039	.15557	.98782	.17279	.98496	3
58	.10395	.99458	.12129	.99262	.13860	.99035	.15586	.98778	.17308	.98491	2
59	.10424	.99455	.12158	.99258	.13889	.99031	.15615	.98773	.17336	.98486	1
60	.10453	.99452	.12187	.99255	.13917	.99027	.15643	.98769	.17365	.98481	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
′	84°		83°		82°		81°		80°		′

NATURAL SINES AND COSINES

′	10°		11°		12°		13°		14°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.17365	.98481	.19081	.98163	.20791	.97815	.22495	.97437	.24192	.97030	60
1	.17393	.98476	.19109	.98157	.20820	.97809	.22523	.97430	.24220	.97023	59
2	.17422	.98471	.19138	.98152	.20848	.97803	.22552	.97424	.24249	.97015	58
3	.17451	.98466	.19167	.98146	.20877	.97797	.22580	.97417	.24277	.97008	57
4	.17479	.98461	.19195	.98140	.20905	.97791	.22608	.97411	.24305	.97001	56
5	.17508	.98455	.19224	.98135	.20933	.97784	.22637	.97404	.24333	.96994	55
6	.17537	.98450	.19252	.98129	.20962	.97778	.22665	.97398	.24362	.96987	54
7	.17565	.98445	.19281	.98124	.20990	.97772	.22693	.97391	.24390	.96980	53
8	.17594	.98440	.19309	.98118	.21019	.97766	.22722	.97384	.24418	.96973	52
9	.17623	.98435	.19338	.98112	.21047	.97760	.22750	.97378	.24446	.96966	51
10	.17651	.98430	.19366	.98107	.21076	.97754	.22778	.97371	.24474	.96959	50
11	.17680	.98425	.19395	.98101	.21104	.97748	.22807	.97365	.24503	.96952	49
12	.17708	.98420	.19423	.98096	.21132	.97742	.22835	.97358	.24531	.96945	48
13	.17737	.98414	.19452	.98090	.21161	.97735	.22863	.97351	.24559	.96937	47
14	.17766	.98409	.19481	.98084	.21189	.97729	.22892	.97345	.24587	.96930	46
15	.17794	.98404	.19509	.98079	.21218	.97723	.22920	.97338	.24615	.96923	45
16	.17823	.98399	.19538	.98073	.21246	.97717	.22948	.97331	.24644	.96916	44
17	.17852	.98394	.19566	.98067	.21275	.97711	.22977	.97325	.24672	.96909	43
18	.17880	.98389	.19595	.98061	.21303	.97705	.23005	.97318	.24700	.96902	42
19	.17909	.98383	.19623	.98056	.21331	.97698	.23033	.97311	.24728	.96894	41
20	.17937	.98378	.19652	.98050	.21360	.97692	.23062	.97304	.24756	.96887	40
21	.17966	.98373	.19680	.98044	.21388	.97686	.23090	.97298	.24784	.96880	39
22	.17995	.98368	.19709	.98039	.21417	.97680	.23118	.97291	.24813	.96873	38
23	.18023	.98362	.19737	.98033	.21445	.97673	.23146	.97284	.24841	.96866	37
24	.18052	.98357	.19766	.98027	.21474	.97667	.23175	.97278	.24869	.96858	36
25	.18081	.98352	.19794	.98021	.21502	.97661	.23203	.97271	.24897	.96851	35
26	.18109	.98347	.19823	.98016	.21530	.97655	.23231	.97264	.24925	.96844	34
27	.18138	.98341	.19851	.98010	.21559	.97648	.23260	.97257	.24954	.96837	33
28	.18166	.98336	.19880	.98004	.21587	.97642	.23288	.97251	.24982	.96829	32
29	.18195	.98331	.19908	.97998	.21616	.97636	.23316	.97244	.25010	.96822	31
30	.18224	.98325	.19937	.97992	.21644	.97630	.23345	.97237	.25038	.96815	30
31	.18252	.98320	.19965	.97987	.21672	.97623	.23373	.97230	.25066	.96807	29
32	.18281	.98315	.19994	.97981	.21701	.97617	.23401	.97223	.25094	.96800	28
33	.18309	.98310	.20022	.97975	.21729	.97611	.23429	.97217	.25122	.96793	27
34	.18338	.98304	.20051	.97969	.21758	.97604	.23458	.97210	.25151	.96786	26
35	.18367	.98299	.20079	.97963	.21786	.97598	.23486	.97203	.25179	.96778	25
36	.18395	.98294	.20108	.97958	.21814	.97592	.23514	.97196	.25207	.96771	24
37	.18424	.98288	.20136	.97952	.21843	.97585	.23542	.97189	.25235	.96764	23
38	.18452	.98283	.20165	.97946	.21871	.97579	.23571	.97182	.25263	.96756	22
39	.18481	.98277	.20193	.97940	.21899	.97573	.23599	.97176	.25291	.96749	21
40	.18509	.98272	.20222	.97934	.21928	.97566	.23627	.97169	.25320	.96742	20
41	.18538	.98267	.20250	.97928	.21956	.97560	.23656	.97162	.25348	.96734	19
42	.18567	.98261	.20279	.97922	.21985	.97553	.23684	.97155	.25376	.96727	18
43	.18595	.98256	.20307	.97916	.22013	.97547	.23712	.97148	.25404	.96719	17
44	.18624	.98250	.20336	.97910	.22041	.97541	.23740	.97141	.25432	.96712	16
45	.18652	.98245	.20364	.97905	.22070	.97534	.23769	.97134	.25460	.96705	15
46	.18681	.98240	.20393	.97899	.22098	.97528	.23797	.97127	.25488	.96697	14
47	.18710	.98234	.20421	.97893	.22126	.97521	.23825	.97120	.25516	.96690	13
48	.18738	.98229	.20450	.97887	.22155	.97515	.23853	.97113	.25545	.96682	12
49	.18767	.98223	.20478	.97881	.22183	.97508	.23882	.97106	.25573	.96675	11
50	.18795	.98218	.20507	.97875	.22212	.97502	.23910	.97100	.25601	.96667	10
51	.18824	.98212	.20535	.97869	.22240	.97496	.23938	.97093	.25629	.96660	9
52	.18852	.98207	.20563	.97863	.22268	.97489	.23966	.97086	.25657	.96653	8
53	.18881	.98201	.20592	.97857	.22297	.97483	.23995	.97079	.25685	.96645	7
54	.18910	.98196	.20620	.97851	.22325	.97476	.24023	.97072	.25713	.96638	6
55	.18938	.98190	.20649	.97845	.22353	.97470	.24051	.97065	.25741	.96630	5
56	.18967	.98185	.20677	.97839	.22382	.97463	.24079	.97058	.25769	.96623	4
57	.18995	.98179	.20706	.97833	.22410	.97457	.24108	.97051	.25798	.96615	3
58	.19024	.98174	.20734	.97827	.22438	.97450	.24136	.97044	.25826	.96608	2
59	.19052	.98168	.20763	.97821	.22467	.97444	.24164	.97037	.25854	.96600	1
60	.19081	.98163	.20791	.97815	.22495	.97437	.24192	.97030	.25882	.96593	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
′	79°		78°		77°		76°		75°		′

NATURAL SINES AND COSINES

′	15°		16°		17°		18°		19°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.25882	.96593	.27564	.96126	.29237	.95630	.30902	.95106	.32557	.94552	60
1	.25910	.96585	.27592	.96118	.29265	.95622	.30929	.95097	.32584	.94542	59
2	.25938	.96578	.27620	.96110	.29293	.95613	.30957	.95088	.32612	.94533	58
3	.25966	.96570	.27648	.96102	.29321	.95605	.30985	.95079	.32639	.94523	57
4	.25994	.96562	.27676	.96094	.29348	.95596	.31012	.95070	.32667	.94514	56
5	.26022	.96555	.27704	.96086	.29376	.95588	.31040	.95061	.32694	.94504	55
6	.26050	.96547	.27731	.96078	.29404	.95579	.31068	.95052	.32722	.94495	54
7	.26079	.96540	.27759	.96070	.29432	.95571	.31095	.95043	.32749	.94485	53
8	.26107	.96532	.27787	.96062	.29460	.95562	.31123	.95033	.32777	.94476	52
9	.26135	.96524	.27815	.96054	.29487	.95554	.31151	.95024	.32804	.94466	51
10	.26163	.96517	.27843	.96046	.29515	.95545	.31178	.95015	.32832	.94457	50
11	.26191	.96509	.27871	.96037	.29543	.95536	.31206	.95006	.32859	.94447	49
12	.26219	.96502	.27899	.96029	.29571	.95528	.31233	.94997	.32887	.94438	48
13	.26247	.96494	.27927	.96021	.29599	.95519	.31261	.94988	.32914	.94428	47
14	.26275	.96486	.27955	.96013	.29626	.95511	.31289	.94979	.32942	.94418	46
15	.26303	.96479	.27983	.96005	.29654	.95502	.31316	.94970	.32969	.94409	45
16	.26331	.96471	.28011	.95997	.29682	.95493	.31344	.94961	.32997	.94399	44
17	.26359	.96463	.28039	.95989	.29710	.95485	.31372	.94952	.33024	.94390	43
18	.26387	.96456	.28067	.95981	.29737	.95476	.31399	.94943	.33051	.94380	42
19	.26415	.96448	.28095	.95972	.29765	.95467	.31427	.94933	.33079	.94370	41
20	.26443	.96440	.28123	.95964	.29793	.95459	.31454	.94924	.33106	.94361	40
21	.26471	.96433	.28150	.95956	.29821	.95450	.31482	.94915	.33134	.94351	39
22	.26500	.96425	.28178	.95948	.29849	.95441	.31510	.94906	.33161	.94342	38
23	.26528	.96417	.28206	.95940	.29876	.95433	.31537	.94897	.33189	.94332	37
24	.26556	.96410	.28234	.95931	.29904	.95424	.31565	.94888	.33216	.94322	36
25	.26584	.96402	.28262	.95923	.29932	.95415	.31593	.94878	.33244	.94313	35
26	.26612	.96394	.28290	.95915	.29960	.95407	.31620	.94869	.33271	.94303	34
27	.26640	.96386	.28318	.95907	.29987	.95398	.31648	.94860	.33298	.94293	33
28	.26668	.96379	.28346	.95898	.30015	.95389	.31675	.94851	.33326	.94284	32
29	.26696	.96371	.28374	.95890	.30043	.95380	.31703	.94842	.33353	.94274	31
30	.26724	.96363	.28402	.95882	.30071	.95372	.31730	.94832	.33381	.94264	30
31	.26752	.96355	.28429	.95874	.30098	.95363	.31758	.94823	.33408	.94254	29
32	.26780	.96347	.28457	.95865	.30126	.95354	.31786	.94814	.33436	.94245	28
33	.26808	.96340	.28485	.95857	.30154	.95345	.31813	.94805	.33463	.94235	27
34	.26836	.96332	.28513	.95849	.30182	.95337	.31841	.94795	.33490	.94225	26
35	.26864	.96324	.28541	.95841	.30209	.95328	.31868	.94786	.33518	.94215	25
36	.26892	.96316	.28569	.95832	.30237	.95319	.31896	.94777	.33545	.94206	24
37	.26920	.96308	.28597	.95824	.30265	.95310	.31923	.94768	.33573	.94196	23
38	.26948	.96301	.28625	.95816	.30292	.95301	.31951	.94758	.33600	.94186	22
39	.26976	.96293	.28652	.95807	.30320	.95293	.31979	.94749	.33627	.94176	21
40	.27004	.96285	.28680	.95799	.30348	.95284	.32006	.94740	.33655	.94167	20
41	.27032	.96277	.28708	.95791	.30376	.95275	.32034	.94730	.33682	.94157	19
42	.27060	.96269	.28736	.95782	.30403	.95266	.32061	.94721	.33710	.94147	18
43	.27088	.96261	.28764	.95774	.30431	.95257	.32089	.94712	.33737	.94137	17
44	.27116	.96253	.28792	.95766	.30459	.95248	.32116	.94702	.33764	.94127	16
45	.27144	.96246	.28820	.95757	.30486	.95240	.32144	.94693	.33792	.94118	15
46	.27172	.96238	.28847	.95749	.30514	.95231	.32171	.94684	.33819	.94108	14
47	.27200	.96230	.28875	.95740	.30542	.95222	.32199	.94674	.33846	.94098	13
48	.27228	.96222	.28903	.95732	.30570	.95213	.32227	.94665	.33874	.94088	12
49	.27256	.96214	.28931	.95724	.30597	.95204	.32254	.94656	.33901	.94078	11
50	.27284	.96206	.28959	.95715	.30625	.95195	.32282	.94646	.33929	.94068	10
51	.27312	.96198	.28987	.95707	.30653	.95186	.32309	.94637	.33956	.94058	9
52	.27340	.96190	.29015	.95698	.30680	.95177	.32337	.94627	.33983	.94049	8
53	.27368	.96182	.29042	.95690	.30708	.95168	.32364	.94618	.34011	.94039	7
54	.27396	.96174	.29070	.95681	.30736	.95159	.32392	.94609	.34038	.94029	6
55	.27424	.96166	.29098	.95673	.30763	.95150	.32419	.94599	.34065	.94019	5
56	.27452	.96158	.29126	.95664	.30791	.95142	.32447	.94590	.34093	.94009	4
57	.27480	.96150	.29154	.95656	.30819	.95133	.32474	.94580	.34120	.93999	3
58	.27508	.96142	.29182	.95647	.30846	.95124	.32502	.94571	.34147	.93989	2
59	.27536	.96134	.29209	.95639	.30874	.95115	.32529	.94561	.34175	.93979	1
60	.27564	.96126	.29237	.95630	.30902	.95106	.32557	.94552	.34202	.93969	0
′	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	′
	74°		73°		72°		[illegible]		70°		

NATURAL SINES AND COSINES

′	20°		21°		22°		23°		24°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.34202	.93969	.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	60
1	.34229	.93959	.35864	.93348	.37488	.92707	.39100	.92039	.40700	.91343	59
2	.34257	.93949	.35891	.93337	.37515	.92697	.39127	.92028	.40727	.91331	58
3	.34284	.93939	.35918	.93327	.37542	.92686	.39153	.92016	.40753	.91319	57
4	.34311	.93929	.35945	.93316	.37569	.92675	.39180	.92005	.40780	.91307	56
5	.34339	.93919	.35973	.93306	.37595	.92664	.39207	.91994	.40806	.91295	55
6	.34366	.93909	.36000	.93295	.37622	.92653	.39234	.91982	.40833	.91283	54
7	.34393	.93899	.36027	.93285	.37649	.92642	.39260	.91971	.40860	.91272	53
8	.34421	.93889	.36054	.93274	.37676	.92631	.39287	.91959	.40886	.91260	52
9	.34448	.93879	.36081	.93264	.37703	.92620	.39314	.91948	.40913	.91248	51
10	.34475	.93869	.36108	.93253	.37730	.92609	.39341	.91936	.40939	.91236	50
11	.34503	.93859	.36135	.93243	.37757	.92598	.39367	.91925	.40966	.91224	49
12	.34530	.93849	.36162	.93232	.37784	.92587	.39394	.91914	.40992	.91212	48
13	.34557	.93839	.36190	.93222	.37811	.92576	.39421	.91902	.41019	.91200	47
14	.34584	.93829	.36217	.93211	.37838	.92565	.39448	.91891	.41045	.91188	46
15	.34612	.93819	.36244	.93201	.37865	.92554	.39474	.91879	.41072	.91176	45
16	.34639	.93809	.36271	.93190	.37892	.92543	.39501	.91868	.41098	.91164	44
17	.34666	.93799	.36298	.93180	.37919	.92532	.39528	.91856	.41125	.91152	43
18	.34694	.93789	.36325	.93169	.37946	.92521	.39555	.91845	.41151	.91140	42
19	.34721	.93779	.36352	.93159	.37973	.92510	.39581	.91833	.41178	.91128	41
20	.34748	.93769	.36379	.93148	.37999	.92499	.39608	.91822	.41204	.91116	40
21	.34775	.93759	.36406	.93137	.38026	.92488	.39635	.91810	.41231	.91104	39
22	.34803	.93748	.36434	.93127	.38053	.92477	.39661	.91799	.41257	.91092	38
23	.34830	.93738	.36461	.93116	.38080	.92466	.39688	.91787	.41284	.91080	37
24	.34857	.93728	.36488	.93106	.38107	.92455	.39715	.91775	.41310	.91068	36
25	.34884	.93718	.36515	.93095	.38134	.92444	.39741	.91764	.41337	.91056	35
26	.34912	.93708	.36542	.93084	.38161	.92432	.39768	.91752	.41363	.91044	34
27	.34939	.93698	.36569	.93074	.38188	.92421	.39795	.91741	.41390	.91032	33
28	.34966	.93688	.36596	.93063	.38215	.92410	.39822	.91729	.41416	.91020	32
29	.34993	.93677	.36623	.93052	.38241	.92399	.39848	.91718	.41443	.91008	31
30	.35021	.93667	.36650	.93042	.38268	.92388	.39875	.91706	.41469	.90996	30
31	.35048	.93657	.36677	.93031	.38295	.92377	.39902	.91694	.41496	.90984	29
32	.35075	.93647	.36704	.93020	.38322	.92366	.39928	.91683	.41522	.90972	28
33	.35102	.93637	.36731	.93010	.38349	.92355	.39955	.91671	.41549	.90960	27
34	.35130	.93626	.36758	.92999	.38376	.92343	.39982	.91660	.41575	.90948	26
35	.35157	.93616	.36785	.92988	.38403	.92332	.40008	.91648	.41602	.90936	25
36	.35184	.93606	.36812	.92978	.38430	.92321	.40035	.91636	.41628	.90924	24
37	.35211	.93596	.36839	.92967	.38456	.92310	.40062	.91625	.41655	.90911	23
38	.35239	.93585	.36867	.92956	.38483	.92299	.40088	.91613	.41681	.90899	22
39	.35266	.93575	.36894	.92945	.38510	.92287	.40115	.91601	.41707	.90887	21
40	.35293	.93565	.36921	.92935	.38537	.92276	.40141	.91590	.41734	.90875	20
41	.35320	.93555	.36948	.92924	.38564	.92265	.40168	.91578	.41760	.90863	19
42	.35347	.93544	.36975	.92913	.38591	.92254	.40195	.91566	.41787	.90851	18
43	.35375	.93534	.37002	.92902	.38617	.92243	.40221	.91555	.41813	.90839	17
44	.35402	.93524	.37029	.92892	.38644	.92231	.40248	.91543	.41840	.90826	16
45	.35429	.93514	.37056	.92881	.38671	.92220	.40275	.91531	.41866	.90814	15
46	.35456	.93503	.37083	.92870	.38698	.92209	.40301	.91519	.41892	.90802	14
47	.35484	.93493	.37110	.92859	.38725	.92198	.40328	.91508	.41919	.90790	13
48	.35511	.93483	.37137	.92849	.38752	.92186	.40355	.91496	.41945	.90778	12
49	.35538	.93472	.37164	.92838	.38778	.92175	.40381	.91484	.41972	.90766	11
50	.35565	.93462	.37191	.92827	.38805	.92164	.40408	.91472	.41998	.90753	10
51	.35592	.93452	.37218	.92816	.38832	.92152	.40434	.91461	.42024	.90741	9
52	.35619	.93441	.37245	.92805	.38859	.92141	.40461	.91449	.42051	.90729	8
53	.35647	.93431	.37272	.92794	.38886	.92130	.40488	.91437	.42077	.90717	7
54	.35674	.93420	.37299	.92784	.38912	.92119	.40514	.91425	.42104	.90704	6
55	.35701	.93410	.37326	.92773	.38939	.92107	.40541	.91414	.42130	.90692	5
56	.35728	.93400	.37353	.92762	.38966	.92096	.40567	.91402	.42156	.90680	4
57	.35755	.93389	.37380	.92751	.38993	.92085	.40594	.91390	.42183	.90668	3
58	.35782	.93379	.37407	.92740	.39020	.92073	.40621	.91378	.42209	.90655	2
59	.35810	.93368	.37434	.92729	.39046	.92062	.40647	.91366	.42235	.90643	1
60	.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	.42262	.90631	0
′	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	′
	69°		68°		67°		66°		65°		

NATURAL SINES AND COSINES

′	25°		26°		27°		28°		29°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.42262	.90631	.43837	.89879	.45399	.89101	.46947	.88295	.48481	.87462	60
1	.42288	.90618	.43863	.89867	.45425	.89087	.46973	.88281	.48506	.87448	59
2	.42315	.90606	.43889	.89854	.45451	.89074	.46999	.88267	.48532	.87434	58
3	.42341	.90594	.43916	.89841	.45477	.89061	.47024	.88254	.48557	.87420	57
4	.42367	.90582	.43942	.89828	.45503	.89048	.47050	.88240	.48583	.87406	56
5	.42394	.90569	.43968	.89816	.45529	.89035	.47076	.88226	.48608	.87391	55
6	.42420	.90557	.43994	.89803	.45554	.89021	.47101	.88213	.48634	.87377	54
7	.42446	.90545	.44020	.89790	.45580	.89008	.47127	.88199	.48659	.87363	53
8	.42473	.90532	.44046	.89777	.45606	.88995	.47153	.88185	.48684	.87349	52
9	.42499	.90520	.44072	.89764	.45632	.88981	.47178	.88172	.48710	.87335	51
10	.42525	.90507	.44098	.89752	.45658	.88968	.47204	.88158	.48735	.87321	50
11	.42552	.90495	.44124	.89739	.45684	.88955	.47229	.88144	.48761	.87306	49
12	.42578	.90483	.44151	.89726	.45710	.88942	.47255	.88130	.48786	.87292	48
13	.42604	.90470	.44177	.89713	.45736	.88928	.47281	.88117	.48811	.87278	47
14	.42631	.90458	.44203	.89700	.45762	.88915	.47306	.88103	.48837	.87264	46
15	.42657	.90446	.44229	.89687	.45787	.88902	.47332	.88089	.48862	.87250	45
16	.42683	.90433	.44255	.89674	.45813	.88888	.47358	.88075	.48888	.87235	44
17	.42709	.90421	.44281	.89662	.45839	.88875	.47383	.88062	.48913	.87221	43
18	.42736	.90408	.44307	.89649	.45865	.88862	.47409	.88048	.48938	.87207	42
19	.42762	.90396	.44333	.89636	.45891	.88848	.47434	.88034	.48964	.87193	41
20	.42788	.90383	.44359	.89623	.45917	.88835	.47460	.88020	.48989	.87178	40
21	.42815	.90371	.44385	.89610	.45942	.88822	.47486	.88006	.49014	.87164	39
22	.42841	.90358	.44411	.89597	.45968	.88808	.47511	.87993	.49040	.87150	38
23	.42867	.90346	.44437	.89584	.45994	.88795	.47537	.87979	.49065	.87136	37
24	.42894	.90334	.44464	.89571	.46020	.88782	.47562	.87965	.49090	.87121	36
25	.42920	.90321	.44490	.89558	.46046	.88768	.47588	.87951	.49116	.87107	35
26	.42946	.90309	.44516	.89545	.46072	.88755	.47614	.87937	.49141	.87093	34
27	.42972	.90296	.44542	.89532	.46097	.88741	.47639	.87923	.49166	.87079	33
28	.42999	.90284	.44568	.89519	.46123	.88728	.47665	.87909	.49192	.87064	32
29	.43025	.90271	.44594	.89506	.46149	.88715	.47690	.87896	.49217	.87050	31
30	.43051	.90259	.44620	.89493	.46175	.88701	.47716	.87882	.49242	.87036	30
31	.43077	.90246	.44646	.89480	.46201	.88688	.47741	.87868	.49268	.87021	29
32	.43104	.90233	.44672	.89467	.46226	.88674	.47767	.87854	.49293	.87007	28
33	.43130	.90221	.44698	.89454	.46252	.88661	.47793	.87840	.49318	.86993	27
34	.43156	.90208	.44724	.89441	.46278	.88647	.47818	.87826	.49344	.86978	26
35	.43182	.90196	.44750	.89428	.46304	.88634	.47844	.87812	.49369	.86964	25
36	.43209	.90183	.44776	.89415	.46330	.88620	.47869	.87798	.49394	.86949	24
37	.43235	.90171	.44802	.89402	.46355	.88607	.47895	.87784	.49419	.86935	23
38	.43261	.90158	.44828	.89389	.46381	.88593	.47920	.87770	.49445	.86921	22
39	.43287	.90146	.44854	.89376	.46407	.88580	.47946	.87756	.49470	.86906	21
40	.43313	.90133	.44880	.89363	.46433	.88566	.47971	.87743	.49495	.86892	20
41	.43340	.90120	.44906	.89350	.46458	.88553	.47997	.87729	.49521	.86878	19
42	.43366	.90108	.44932	.89337	.46484	.88539	.48022	.87715	.49546	.86863	18
43	.43392	.90095	.44958	.89324	.46510	.88526	.48048	.87701	.49571	.86849	17
44	.43418	.90082	.44984	.89311	.46536	.88512	.48073	.87687	.49596	.86834	16
45	.43445	.90070	.45010	.89298	.46561	.88499	.48099	.87673	.49622	.86820	15
46	.43471	.90057	.45036	.89285	.46587	.88485	.48124	.87659	.49647	.86805	14
47	.43497	.90045	.45062	.89272	.46613	.88472	.48150	.87645	.49672	.86791	13
48	.43523	.90032	.45088	.89259	.46639	.88458	.48175	.87631	.49697	.86777	12
49	.43549	.90019	.45114	.89245	.46664	.88445	.48201	.87617	.49723	.86762	11
50	.43575	.90007	.45140	.89232	.46690	.88431	.48226	.87603	.49748	.86748	10
51	.43602	.89994	.45166	.89219	.46716	.88417	.48252	.87589	.49773	.86733	9
52	.43628	.89981	.45192	.89206	.46742	.88404	.48277	.87575	.49798	.86719	8
53	.43654	.89968	.45218	.89193	.46767	.88390	.48303	.87561	.49824	.86704	7
54	.43680	.89956	.45243	.89180	.46793	.88377	.48328	.87546	.49849	.86690	6
55	.43706	.89943	.45269	.89167	.46819	.88363	.48354	.87532	.49874	.86675	5
56	.43733	.89930	.45295	.89153	.46844	.88349	.48379	.87518	.49899	.86661	4
57	.43759	.89918	.45321	.89140	.46870	.88336	.48405	.87504	.49924	.86646	3
58	.43785	.89905	.45347	.89127	.46896	.88322	.48430	.87490	.49950	.86632	2
59	.43811	.89892	.45373	.89114	.46921	.88308	.48456	.87476	.49975	.86617	1
60	.43837	.89879	.45399	.89101	.46947	.88295	.48481	.87462	.50000	.86603	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
′	64°		63°		62°		61°		60°		′

NATURAL SINES AND COSINES

′	30°		31°		32°		33°		34°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.50000	.86603	.51504	.85717	.52992	.84805	.54464	.83867	.55919	.82904	60
1	.50025	.86588	.51529	.85702	.53017	.84789	.54488	.83851	.55943	.82887	59
2	.50050	.86573	.51554	.85687	.53041	.84774	.54513	.83835	.55968	.82871	58
3	.50076	.86559	.51579	.85672	.53066	.84759	.54537	.83819	.55992	.82855	57
4	.50101	.86544	.51604	.85657	.53091	.84743	.54561	.83804	.56016	.82839	56
5	.50126	.86530	.51628	.85642	.53115	.84728	.54586	.83788	.56040	.82822	55
6	.50151	.86515	.51653	.85627	.53140	.84712	.54610	.83772	.56064	.82806	54
7	.50176	.86501	.51678	.85612	.53164	.84697	.54635	.83756	.56088	.82790	53
8	.50201	.86486	.51703	.85597	.53189	.84681	.54659	.83740	.56112	.82773	52
9	.50227	.86471	.51728	.85582	.53214	.84666	.54683	.83724	.56136	.82757	51
10	.50252	.86457	.51753	.85567	.53238	.84650	.54708	.83708	.56160	.82741	50
11	.50277	.86442	.51778	.85551	.53263	.84635	.54732	.83692	.56184	.82724	49
12	.50302	.86427	.51803	.85536	.53288	.84619	.54756	.83676	.56208	.82708	48
13	.50327	.86413	.51828	.85521	.53312	.84604	.54781	.83660	.56232	.82692	47
14	.50352	.86398	.51852	.85506	.53337	.84588	.54805	.83645	.56256	.82675	46
15	.50377	.86384	.51877	.85491	.53361	.84573	.54829	.83629	.56280	.82659	45
16	.50403	.86369	.51902	.85476	.53386	.84557	.54854	.83613	.56305	.82643	44
17	.50428	.86354	.51927	.85461	.53411	.84542	.54878	.83597	.56329	.82626	43
18	.50453	.86340	.51952	.85446	.53435	.84526	.54902	.83581	.56353	.82610	42
19	.50478	.86325	.51977	.85431	.53460	.84511	.54927	.83565	.56377	.82593	41
20	.50503	.86310	.52002	.85416	.53484	.84495	.54951	.83549	.56401	.82577	40
21	.50528	.86295	.52026	.85401	.53509	.84480	.54975	.83533	.56425	.82561	39
22	.50553	.86281	.52051	.85385	.53534	.84464	.54999	.83517	.56449	.82544	38
23	.50578	.86266	.52076	.85370	.53558	.84448	.55024	.83501	.56473	.82528	37
24	.50603	.86251	.52101	.85355	.53583	.84433	.55048	.83485	.56497	.82511	36
25	.50628	.86237	.52126	.85340	.53607	.84417	.55072	.83469	.56521	.82495	35
26	.50654	.86222	.52151	.85325	.53632	.84402	.55097	.83453	.56545	.82478	34
27	.50679	.86207	.52175	.85310	.53656	.84386	.55121	.83437	.56569	.82462	33
28	.50704	.86192	.52200	.85294	.53681	.84370	.55145	.83421	.56593	.82446	32
29	.50729	.86178	.52225	.85279	.53705	.84355	.55169	.83405	.56617	.82429	31
30	.50754	.86163	.52250	.85264	.53730	.84339	.55194	.83389	.56641	.82413	30
31	.50779	.86148	.52275	.85249	.53754	.84324	.55218	.83373	.56665	.82396	29
32	.50804	.86133	.52299	.85234	.53779	.84308	.55242	.83356	.56689	.82380	28
33	.50829	.86119	.52324	.85218	.53804	.84292	.55266	.83340	.56713	.82363	27
34	.50854	.86104	.52349	.85203	.53828	.84277	.55291	.83324	.56736	.82347	26
35	.50879	.86089	.52374	.85188	.53853	.84261	.55315	.83308	.56760	.82330	25
36	.50904	.86074	.52399	.85173	.53877	.84245	.55339	.83292	.56784	.82314	24
37	.50929	.86059	.52423	.85157	.53902	.84230	.55363	.83276	.56808	.82297	23
38	.50954	.86045	.52448	.85142	.53926	.84214	.55388	.83260	.56832	.82281	22
39	.50979	.86030	.52473	.85127	.53951	.84198	.55412	.83244	.56856	.82264	21
40	.51004	.86015	.52498	.85112	.53975	.84182	.55436	.83228	.56880	.82248	20
41	.51029	.86000	.52522	.85096	.54000	.84167	.55460	.83212	.56904	.82231	19
42	.51054	.85985	.52547	.85081	.54024	.84151	.55484	.83195	.56928	.82214	18
43	.51079	.85970	.52572	.85066	.54049	.84135	.55509	.83179	.56952	.82198	17
44	.51104	.85956	.52597	.85051	.54073	.84120	.55533	.83163	.56976	.82181	16
45	.51129	.85941	.52621	.85035	.54097	.84104	.55557	.83147	.57000	.82165	15
46	.51154	.85926	.52646	.85020	.54122	.84088	.55581	.83131	.57024	.82148	14
47	.51179	.85911	.52671	.85005	.54146	.84072	.55605	.83115	.57047	.82132	13
48	.51204	.85896	.52696	.84989	.54171	.84057	.55630	.83098	.57071	.82115	12
49	.51229	.85881	.52720	.84974	.54195	.84041	.55654	.83083	.57095	.82098	11
50	.51254	.85866	.52745	.84959	.54220	.84025	.55678	.83066	.57119	.82082	10
51	.51279	.85851	.52770	.84943	.54244	.84009	.55702	.83050	.57143	.82065	9
52	.51304	.85836	.52794	.84928	.54269	.83994	.55726	.83034	.57167	.82048	8
53	.51329	.85821	.52819	.84913	.54293	.83978	.55750	.83017	.57191	.82032	7
54	.51354	.85806	.52844	.84897	.54317	.83962	.55775	.83001	.57215	.82015	6
55	.51379	.85792	.52869	.84882	.54342	.83946	.55799	.82985	.57238	.81999	5
56	.51404	.85777	.52893	.84866	.54366	.83930	.55823	.82969	.57262	.81982	4
57	.51429	.85762	.52918	.84851	.54391	.83915	.55847	.82953	.57286	.81965	3
58	.51454	.85747	.52943	.84836	.54415	.83899	.55871	.82936	.57310	.81949	2
59	.51479	.85732	.52967	.84820	.54440	.83883	.55895	.82920	.57334	.81932	1
60	.51504	.85717	.52992	.84805	.54464	.83867	.55919	.82904	.57358	.81915	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
′	59°		58°		57°		56°		55°		′

NATURAL SINES AND COSINES

′	35°		36°		37°		38°		39°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.57358	.81915	.58779	.80902	.60182	.79864	.61566	.78801	.62932	.77715	60
1	.57381	.81899	.58802	.80885	.60205	.79846	.61589	.78783	.62955	.77696	59
2	.57405	.81882	.58826	.80867	.60228	.79829	.61612	.78765	.62977	.77678	58
3	.57429	.81865	.58849	.80850	.60251	.79811	.61635	.78747	.63000	.77660	57
4	.57453	.81848	.58873	.80833	.60274	.79793	.61658	.78729	.63022	.77641	56
5	.57477	.81832	.58896	.80816	.60298	.79776	.61681	.78711	.63045	.77623	55
6	.57501	.81815	.58920	.80799	.60321	.79758	.61704	.78694	.63068	.77605	54
7	.57524	.81798	.58943	.80782	.60344	.79741	.61726	.78676	.63090	.77586	53
8	.57548	.81782	.58967	.80765	.60367	.79723	.61749	.78658	.63113	.77568	52
9	.57572	.81765	.58990	.80748	.60390	.79706	.61772	.78640	.63135	.77550	51
10	.57596	.81748	.59014	.80730	.60414	.79688	.61795	.78622	.63158	.77531	50
11	.57619	.81731	.59037	.80713	.60437	.79671	.61818	.78604	.63180	.77513	49
12	.57643	.81714	.59061	.80696	.60460	.79653	.61841	.78586	.63203	.77494	48
13	.57667	.81698	.59084	.80679	.60483	.79635	.61864	.78568	.63225	.77476	47
14	.57691	.81681	.59108	.80662	.60506	.79618	.61887	.78550	.63248	.77458	46
15	.57715	.81664	.59131	.80644	.60529	.79600	.61909	.78532	.63271	.77439	45
16	.57738	.81647	.59154	.80627	.60553	.79583	.61932	.78514	.63293	.77421	44
17	.57762	.81631	.59178	.80610	.60576	.79565	.61955	.78496	.63316	.77402	43
18	.57786	.81614	.59201	.80593	.60599	.79547	.61978	.78478	.63338	.77384	42
19	.57810	.81597	.59225	.80576	.60622	.79530	.62001	.78460	.63361	.77366	41
20	.57833	.81580	.59248	.80558	.60645	.79512	.62024	.78442	.63383	.77347	40
21	.57857	.81563	.59272	.80541	.60668	.79494	.62046	.78424	.63406	.77329	39
22	.57881	.81546	.59295	.80524	.60691	.79477	.62069	.78405	.63428	.77310	38
23	.57904	.81530	.59318	.80507	.60714	.79459	.62092	.78387	.63451	.77292	37
24	.57928	.81513	.59342	.80489	.60738	.79441	.62115	.78369	.63473	.77273	36
25	.57952	.81496	.59365	.80472	.60761	.79424	.62138	.78351	.63496	.77255	35
26	.57976	.81479	.59389	.80455	.60784	.79406	.62160	.78333	.63518	.77236	34
27	.57999	.81462	.59412	.80438	.60807	.79388	.62183	.78315	.63540	.77218	33
28	.58023	.81445	.59436	.80420	.60830	.79371	.62206	.78297	.63563	.77199	32
29	.58047	.81428	.59459	.80403	.60853	.79353	.62229	.78279	.63585	.77181	31
30	.58070	.81412	.59482	.80386	.60876	.79335	.62251	.78261	.63608	.77162	30
31	.58094	.81395	.59506	.80368	.60899	.79318	.62274	.78243	.63630	.77144	29
32	.58118	.81378	.59529	.80351	.60922	.79300	.62297	.78225	.63653	.77125	28
33	.58141	.81361	.59552	.80334	.60945	.79282	.62320	.78206	.63675	.77107	27
34	.58165	.81344	.59576	.80316	.60968	.79264	.62342	.78188	.63698	.77088	26
35	.58189	.81327	.59599	.80299	.60991	.79247	.62365	.78170	.63720	.77070	25
36	.58212	.81310	.59622	.80282	.61015	.79229	.62388	.78152	.63742	.77051	24
37	.58236	.81293	.59646	.80264	.61038	.79211	.62411	.78134	.63765	.77033	23
38	.58260	.81276	.59669	.80247	.61061	.79193	.62433	.78116	.63787	.77014	22
39	.58283	.81259	.59693	.80230	.61084	.79176	.62456	.78098	.63810	.76996	21
40	.58307	.81242	.59716	.80212	.61107	.79158	.62479	.78079	.63832	.76977	20
41	.58330	.81225	.59739	.80195	.61130	.79140	.62502	.78061	.63854	.76959	19
42	.58354	.81208	.59763	.80178	.61153	.79122	.62524	.78043	.63877	.76940	18
43	.58378	.81191	.59786	.80160	.61176	.79105	.62547	.78025	.63899	.76921	17
44	.58401	.81174	.59809	.80143	.61199	.79087	.62570	.78007	.63922	.76903	16
45	.58425	.81157	.59832	.80125	.61222	.79069	.62592	.77988	.63944	.76884	15
46	.58449	.81140	.59856	.80108	.61245	.79051	.62615	.77970	.63966	.76866	14
47	.58472	.81123	.59879	.80091	.61268	.79033	.62638	.77952	.63989	.76847	13
48	.58496	.81106	.59902	.80073	.61291	.79016	.62660	.77934	.64011	.76828	12
49	.58519	.81089	.59926	.80056	.61314	.78998	.62683	.77916	.64033	.76810	11
50	.58543	.81072	.59949	.80038	.61337	.78980	.62706	.77897	.64056	.76791	10
51	.58567	.81055	.59972	.80021	.61360	.78962	.62728	.77879	.64078	.76772	9
52	.58590	.81038	.59995	.80003	.61383	.78944	.62751	.77861	.64100	.76754	8
53	.58614	.81021	.60019	.79986	.61406	.78926	.62774	.77843	.64123	.76735	7
54	.58637	.81004	.60042	.79968	.61429	.78908	.62796	.77824	.64145	.76717	6
55	.58661	.80987	.60065	.79951	.61451	.78891	.62819	.77806	.64167	.76698	5
56	.58684	.80970	.60089	.79934	.61474	.78873	.62842	.77788	.64190	.76679	4
57	.58708	.80953	.60112	.79916	.61497	.78855	.62864	.77769	.64212	.76661	3
58	.58731	.80936	.60135	.79899	.61520	.78837	.62887	.77751	.64234	.76642	2
59	.58755	.80919	.60158	.79881	.61543	.78819	.62909	.77733	.64256	.76623	1
60	.58779	.80902	.60182	.79864	.61566	.78801	.62932	.77715	.64279	.76604	0
′	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	′
	54°		53°		52°		51°		50°		

NATURAL SINES AND COSINES

′	40°		41°		42°		43°		44°		′
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.64279	.76604	.65606	.75471	.66913	.74314	.68200	.73135	.69466	.71934	60
1	.64301	.76586	.65628	.75452	.66935	.74295	.68221	.73116	.69487	.71914	59
2	.64323	.76567	.65650	.75433	.66956	.74276	.68242	.73096	.69508	.71894	58
3	.64346	.76548	.65672	.75414	.66978	.74256	.68264	.73076	.69529	.71873	57
4	.64368	.76530	.65694	.75395	.66999	.74237	.68285	.73056	.69549	.71853	56
5	.64390	.76511	.65716	.75375	.67021	.74217	.68306	.73036	.69570	.71833	55
6	.64412	.76492	.65738	.75356	.67043	.74198	.68327	.73016	.69591	.71813	54
7	.64435	.76473	.65759	.75337	.67064	.74178	.68349	.72996	.69612	.71792	53
8	.64457	.76455	.65781	.75318	.67086	.74159	.68370	.72976	.69633	.71772	52
9	.64479	.76436	.65803	.75299	.67107	.74139	.68391	.72957	.69654	.71752	51
10	.64501	.76417	.65825	.75280	.67129	.74120	.68412	.72937	.69675	.71732	50
11	.64524	.76398	.65847	.75261	.67151	.74100	.68434	.72917	.69696	.71711	49
12	.64546	.76380	.65869	.75241	.67172	.74080	.68455	.72897	.69717	.71691	48
13	.64568	.76361	.65891	.75222	.67194	.74061	.68476	.72877	.69737	.71671	47
14	.64590	.76342	.65913	.75203	.67215	.74041	.68497	.72857	.69758	.71650	46
15	.64612	.76323	.65935	.75184	.67237	.74022	.68518	.72837	.69779	.71630	45
16	.64635	.76304	.65956	.75165	.67258	.74002	.68539	.72817	.69800	.71610	44
17	.64657	.76286	.65978	.75146	.67280	.73983	.68561	.72797	.69821	.71590	43
18	.64679	.76267	.66000	.75126	.67301	.73963	.68582	.72777	.69842	.71569	42
19	.64701	.76248	.66022	.75107	.67323	.73944	.68603	.72757	.69862	.71549	41
20	.64723	.76229	.66044	.75088	.67344	.73924	.68624	.72737	.69883	.71529	40
21	.64746	.76210	.66066	.75069	.67366	.73904	.68645	.72717	.69904	.71508	39
22	.64768	.76192	.66088	.75050	.67387	.73885	.68666	.72697	.69925	.71488	38
23	.64790	.76173	.66109	.75030	.67409	.73865	.68688	.72677	.69946	.71468	37
24	.64812	.76154	.66131	.75011	.67430	.73846	.68709	.72657	.69966	.71447	36
25	.64834	.76135	.66153	.74992	.67452	.73826	.68730	.72637	.69987	.71427	35
26	.64856	.76116	.66175	.74973	.67473	.73806	.68751	.72617	.70008	.71407	34
27	.64878	.76097	.66197	.74953	.67495	.73787	.68772	.72597	.70029	.71386	33
28	.64901	.76078	.66218	.74934	.67516	.73767	.68793	.72577	.70049	.71366	32
29	.64923	.76059	.66240	.74915	.67538	.73747	.68814	.72557	.70070	.71345	31
30	.64945	.76041	.66262	.74896	.67559	.73728	.68835	.72537	.70091	.71325	30
31	.64967	.76022	.66284	.74876	.67580	.73708	.68857	.72517	.70112	.71305	29
32	.64989	.76003	.66306	.74857	.67602	.73688	.68878	.72497	.70132	.71284	28
33	.65011	.75984	.66327	.74838	.67623	.73669	.68899	.72477	.70153	.71264	27
34	.65033	.75965	.66349	.74818	.67645	.73649	.68920	.72457	.70174	.71243	26
35	.65055	.75946	.66371	.74799	.67666	.73629	.68941	.72437	.70195	.71223	25
36	.65077	.75927	.66393	.74780	.67688	.73610	.68962	.72417	.70215	.71203	24
37	.65100	.75908	.66414	.74760	.67709	.73590	.68983	.72397	.70236	.71182	23
38	.65122	.75889	.66436	.74741	.67730	.73570	.69004	.72377	.70257	.71162	22
39	.65144	.75870	.66458	.74722	.67752	.73551	.69025	.72357	.70277	.71141	21
40	.65166	.75851	.66480	.74703	.67773	.73531	.69046	.72337	.70298	.71121	20
41	.65188	.75832	.66501	.74683	.67795	.73511	.69067	.72317	.70319	.71100	19
42	.65210	.75813	.66523	.74664	.67816	.73491	.69088	.72297	.70339	.71080	18
43	.65232	.75794	.66545	.74644	.67837	.73472	.69109	.72277	.70360	.71059	17
44	.65254	.75775	.66566	.74625	.67859	.73452	.69130	.72257	.70381	.71039	16
45	.65276	.75756	.66588	.74606	.67880	.73432	.69151	.72236	.70401	.71019	15
46	.65298	.75738	66610	.74586	.67901	.73413	.69172	.72216	.70422	.70998	14
47	.65320	.75719	.66632	.74567	.67923	.73393	.69193	.72196	.70443	.70978	13
48	.65342	.75700	.66653	.74548	.67944	.73373	.69214	.72176	.70463	.70957	12
49	.65364	.75680	.66675	.74528	.67965	.73353	.69235	.72156	.70484	.70937	11
50	.65386	.75661	.66697	.74509	.67987	.73333	.69256	.72136	.70505	.70916	10
51	.65408	.75642	.66718	.74489	.68008	.73314	.69277	.72116	.70525	.70896	9
52	.65430	.75623	.66740	.74470	.68029	.73294	.69298	.72095	.70546	.70875	8
53	.65452	.75604	.66762	.74451	.68051	.73274	.69319	.72075	.70567	.70855	7
54	.65474	.75585	.66783	.74431	.68072	.73254	.69340	.72055	.70587	.70834	6
55	.65496	.75566	.66805	.74412	.68093	.73234	.69361	.72035	.70608	.70813	5
56	.65518	.75547	.66827	.74392	.68115	.73215	.69382	.72015	.70628	.70793	4
57	.65540	.75528	.66848	.74373	.68136	.73195	.69403	.71995	.70649	.70772	3
58	.65562	.75509	.66870	.74353	.68157	.73175	.69424	.71974	.70670	.70752	2
59	.65584	.75490	.66891	.74334	.68179	.73155	.69445	.71954	.70690	.70731	1
60	.65606	.75471	.66913	.74314	.68200	.73135	.69466	.71934	.70711	.70711	0
′	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	′
	49°		48°		47°		46°		45°		

NATURAL TANGENTS AND COTANGENTS

′	0° Tang	0° Cotang	1° Tang	1° Cotang	2° Tang	2° Cotang	3° Tang	3° Cotang	4° Tang	4° Cotang	′
0	.00000	Infinite	.01746	57.2900	.03492	28.6363	.05241	19.0811	.06993	14.3007	60
1	.00029	3437.75	.01775	56.3506	.03521	28.3994	.05270	18.9755	.07022	14.2411	59
2	.00058	1718.87	.01804	55.4415	.03550	28.1664	.05299	18.8711	.07051	14.1821	58
3	.00087	1145.92	.01833	54.5613	.03579	27.9372	.05328	18.7678	.07080	14.1235	57
4	.00116	859.436	.01862	53.7086	.03609	27.7117	.05357	18.6656	.07110	14.0655	56
5	.00145	687.549	.01891	52.8821	.03638	27.4899	.05387	18.5645	.07139	14.0079	55
6	.00175	572.957	.01920	52.0807	.03667	27.2715	.05416	18.4645	.07168	13.9507	54
7	.00204	491.106	.01949	51.3032	.03696	27.0566	.05445	18.3655	.07197	13.8940	53
8	.00233	429.718	.01978	50.5485	.03725	26.8450	.05474	18.2677	.07227	13.8378	52
9	.00262	381.971	.02007	49.8157	.03754	26.6367	.05503	18.1708	.07256	13.7821	51
10	.00291	343.774	.02036	49.1039	.03783	26.4316	.05533	18.0750	.07285	13.7267	50
11	.00320	312.521	.02066	48.4121	.03812	26.2296	.05562	17.9802	.07314	13.6719	49
12	.00349	286.478	.02095	47.7395	.03842	26.0307	.05591	17.8863	.07344	13.6174	48
13	.00378	264.441	.02124	47.0853	.03871	25.8348	.05620	17.7934	.07373	13.5634	47
14	.00407	245.552	.02153	46.4489	.03900	25.6418	.05649	17.7015	.07402	13.5098	46
15	.00436	229.182	.02182	45.8294	.03929	25.4517	.05678	17.6106	.07431	13.4566	45
16	.00465	214.858	.02211	45.2261	.03958	25.2644	.05708	17.5205	.07461	13.4039	44
17	.00495	202.219	.02240	44.6386	.03987	25.0798	.05737	17.4314	.07490	13.3515	43
18	.00524	190.984	.02269	44.0661	.04016	24.8978	.05766	17.3432	.07519	13.2996	42
19	.00553	180.932	.02298	43.5081	.04046	24.7185	.05795	17.2558	.07548	13.2480	41
20	.00582	171.885	.02328	42.9641	.04075	24.5418	.05824	17.1693	.07578	13.1969	40
21	.00611	163.700	.02357	42.4335	.04104	24.3675	.05854	17.0837	.07607	13.1461	39
22	.00640	156.259	.02386	41.9158	.04133	24.1957	.05883	16.9990	.07636	13.0958	38
23	.00669	149.465	.02415	41.4106	.04162	24.0263	.05912	16.9150	.07665	13.0458	37
24	.00698	143.237	.02444	40.9174	.04191	23.8593	.05941	16.8319	.07695	12.9962	36
25	.00727	137.507	.02473	40.4358	.04220	23.6945	.05970	16.7496	.07724	12.9469	35
26	.00756	132.219	.02502	39.9655	.04250	23.5321	.05999	16.6681	.07753	12.8981	34
27	.00785	127.321	.02531	39.5059	.04279	23.3718	.06029	16.5874	.07782	12.8496	33
28	.00815	122.774	.02560	39.0568	.04308	23.2137	.06058	16.5075	.07812	12.8014	32
29	.00844	118.540	.02589	38.6177	.04337	23.0577	.06087	16.4283	.07841	12.7536	31
30	.00873	114.589	.02619	38.1885	.04366	22.9038	.06116	16.3499	.07870	12.7062	30
31	.00902	110.892	.02648	37.7686	.04395	22.7519	.06145	16.2722	.07899	12.6591	29
32	.00931	107.426	.02677	37.3579	.04424	22.6020	.06175	16.1952	.07929	12.6124	28
33	.00960	104.171	.02706	36.9560	.04454	22.4541	.06204	16.1190	.07958	12.5660	27
34	.00989	101.107	.02735	36.5627	.04483	22.3081	.06233	16.0435	.07987	12.5199	26
35	.01018	98.2179	.02764	36.1776	.04512	22.1640	.06262	15.9687	.08017	12.4742	25
36	.01047	95.4895	.02793	35.8006	.04541	22.0217	.06291	15.8945	.08046	12.4288	24
37	.01076	92.9085	.02822	35.4313	.04570	21.8813	.06321	15.8211	.08075	12.3838	23
38	.01105	90.4633	.02851	35.0695	.04599	21.7426	.06350	15.7483	.08104	12.3390	22
39	.01135	83.1436	.02881	34.7151	.04628	21.6056	.06379	15.6762	.08134	12.2946	21
40	.01164	85.9398	.02910	34.3678	.04658	21.4704	.06408	15.6048	.08163	12.2505	20
41	.01193	83.8435	.02939	34.0273	.04687	21.3369	.06437	15.5340	.08192	12.2067	19
42	.01222	81.8470	.02968	33.6935	.04716	21.2049	.06467	15.4638	.08221	12.1632	18
43	.01251	79.9434	.02997	33.3662	.04745	21.0747	.06496	15.3943	.08251	12.1201	17
44	.01280	78.1263	.03026	33.0452	.04774	20.9460	.06525	15.3254	.08280	12.0772	16
45	.01309	76.3900	.03055	32.7303	.04803	20.8188	.06554	15.2571	.08309	12.0346	15
46	.01338	74.7292	.03084	32.4213	.04833	20.6932	.06584	15.1893	.08339	11.9923	14
47	.01367	73.1390	.03114	32.1181	.04862	20.5691	.06613	15.1222	.08368	11.9504	13
48	.01396	71.6151	.03143	31.8205	.04891	20.4465	.06642	15.0557	.08397	11.9087	12
49	.01425	70.1533	.03172	31.5284	.04920	20.3253	.06671	14.9898	.08427	11.8673	11
50	.01455	68.7501	.03201	31.2416	.04949	20.2056	.06700	14.9244	.08456	11.8262	10
51	.01484	67.4019	.03230	30.9599	.04978	20.0872	.06730	14.8596	.08485	11.7853	9
52	.01513	66.1055	.03259	30.6833	.05007	19.9702	.06759	14.7954	.08514	11.7448	8
53	.01542	64.8580	.03288	30.4116	.05037	19.8546	.06788	14.7317	.08544	11.7045	7
54	.01571	63.6567	.03317	30.1446	.05066	19.7403	.06817	14.6685	.08573	11.6645	6
55	.01600	62.4992	.03346	29.8823	.05095	19.6273	.06847	14.6059	.08602	11.6248	5
56	.01629	61.3829	.03376	29.6245	.05124	19.5156	.06876	14.5438	.08632	11.5853	4
57	.01658	60.3058	.03405	29.3711	.05153	19.4051	.06905	14.4823	.08661	11.5461	3
58	.01687	59.2659	.03434	29.1220	.05182	19.2959	.06934	14.4212	.08690	11.5072	2
59	.01716	58.2612	.03463	28.8771	.05212	19.1879	.06963	14.3607	.08720	11.4685	1
60	.01746	57.2900	.03492	28.6363	.05241	19.0811	.06993	14.3007	.08749	11.4301	0
′	89° Cotang	89° Tang	88° Cotang	88° Tang	87° Cotang	87° Tang	86° Cotang	86° Tang	85° Cotang	85° Tang	′

NATURAL TANGENTS AND COTANGENTS

′	5°		6°		7°		8°		9°		′
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.08749	11.4301	.10510	9.51436	.12278	8.14435	.14054	7.11537	.15838	6.31375	60
1	.08778	11.3919	.10540	9.48781	.12308	8.12481	.14084	7.10038	.15868	6.30189	59
2	.08807	11.3540	.10569	9.46141	.12338	8.10536	.14113	7.08546	.15898	6.29007	58
3	.08837	11.3163	.10599	9.43515	.12367	8.08600	.14143	7.07059	.15928	6.27829	57
4	.08866	11.2789	.10628	9.40904	.12397	8.06674	.14173	7.05579	.15958	6.26655	56
5	.08895	11.2417	.10657	9.38307	.12426	8.04756	.14202	7.04105	.15988	6.25486	55
6	.08925	11.2048	.10687	9.35724	.12456	8.02848	.14232	7.02637	.16017	6.24321	54
7	.08954	11.1681	.10716	9.33155	.12485	8.00948	.14262	7.01174	.16047	6.23160	53
8	.08983	11.1316	.10746	9.30599	.12515	7.99058	.14291	6.99718	.16077	6.22003	52
9	.09013	11.0954	.10775	9.28058	.12544	7.97176	.14321	6.98268	.16107	6.20851	51
10	.09042	11.0594	.10805	9.25530	.12574	7.95302	.14351	6.96823	.16137	6.19703	50
11	.09071	11.0237	.10834	9.23016	.12603	7.93438	.14381	6.95385	.16167	6.18559	49
12	.09101	10.9882	.10863	9.20516	.12633	7.91582	.14410	6.93952	.16196	6.17419	48
13	.09130	10.9529	.10893	9.18028	.12662	7.89734	.14440	6.92525	.16226	6.16283	47
14	.09159	10.9178	.10922	9.15554	.12692	7.87895	.14470	6.91104	.16256	6.15151	46
15	.09189	10.8829	.10952	9.13093	.12722	7.86064	.14499	6.89688	.16286	6.14023	45
16	.09218	10.8483	.10981	9.10646	.12751	7.84242	.14529	6.88278	.16316	6.12899	44
17	.09247	10.8139	.11011	9.08211	.12781	7.82428	.14559	6.86874	.16346	6.11779	43
18	.09277	10.7797	.11040	9.05789	.12810	7.80622	.14588	6.85475	.16376	6.10664	42
19	.09306	10.7457	.11070	9.03379	.12840	7.78825	.14618	6.84082	.16405	6.09552	41
20	.09335	10.7119	.11099	9.00983	.12869	7.77035	.14648	6.82694	.16435	6.08444	40
21	.09365	10.6783	.11128	8.98598	.12899	7.75254	.14678	6.81312	.16465	6.07340	39
22	.09394	10.6450	.11158	8.96227	.12929	7.73480	.14707	6.79936	.16495	6.06240	38
23	.09423	10.6118	.11187	8.93867	.12958	7.71715	.14737	6.78564	.16525	6.05143	37
24	.09453	10.5789	.11217	8.91520	.12988	7.69957	.14767	6.77199	.16555	6.04051	36
25	.09482	10.5462	.11246	8.89185	.13017	7.68208	.14796	6.75838	.16585	6.02962	35
26	.09511	10.5136	.11276	8.86862	.13047	7.66466	.14826	6.74483	.16615	6.01878	34
27	.09541	10.4813	.11305	8.84551	.13076	7.64732	.14856	6.73133	.16645	6.00797	33
28	.09570	10.4491	.11335	8.82252	.13106	7.63005	.14886	6.71789	.16674	5.99720	32
29	.09600	10.4172	.11364	8.79964	.13136	7.61287	.14915	6.70450	.16704	5.98646	31
30	.09629	10.3854	.11394	8.77689	.13165	7.59575	.14945	6.69116	.16734	5.97576	30
31	.09658	10.3538	.11423	8.75425	.13195	7.57872	.14975	6.67787	.16764	5.96510	29
32	.09688	10.3224	.11452	8.73172	.13224	7.56176	.15005	6.66463	.16794	5.95448	28
33	.09717	10.2913	.11482	8.70931	.13254	7.54487	.15034	6.65144	.16824	5.94390	27
34	.09746	10.2602	.11511	8.68701	.13284	7.52806	.15064	6.63831	.16854	5.93335	26
35	.09776	10.2294	.11541	8.66482	.13313	7.51132	.15094	6.62523	.16884	5.92283	25
36	.09805	10.1988	.11570	8.64275	.13343	7.49465	.15124	6.61219	.16914	5.91236	24
37	.09834	10.1683	.11600	8.62078	.13372	7.47806	.15153	6.59921	.16944	5.90191	23
38	.09864	10.1381	.11629	8.59893	.13402	7.46154	.15183	6.58627	.16974	5.89151	22
39	.09893	10.1080	.11659	8.57718	.13432	7.44509	.15213	6.57339	.17004	5.88114	21
40	.09923	10.0780	.11688	8.55555	.13461	7.42871	.15243	6.56055	.17033	5.87080	20
41	.09952	10.0483	.11718	8.53402	.13491	7.41240	.15272	6.54777	.17063	5.86051	19
42	.09981	10.0187	.11747	8.51259	.13521	7.39616	.15302	6.53503	.17093	5.85024	18
43	.10011	9.98931	.11777	8.49128	.13550	7.37999	.15332	6.52234	.17123	5.84001	17
44	.10040	9.96007	.11806	8.47007	.13580	7.36389	.15362	6.50970	.17153	5.82982	16
45	.10069	9.93101	.11836	8.44896	.13609	7.34786	.15391	6.49710	.17183	5.81966	15
46	.10099	9.90211	.11865	8.42795	.13639	7.33190	.15421	6.48456	.17213	5.80953	14
47	.10128	9.87338	.11895	8.40705	.13669	7.31600	.15451	6.47206	.17243	5.79944	13
48	.10158	9.84482	.11924	8.38625	.13698	7.30018	.15481	6.45961	.17273	5.78938	12
49	.10187	9.81641	.11954	8.36555	.13728	7.28442	.15511	6.44720	.17303	5.77936	11
50	.10216	9.78817	.11983	8.34496	.13758	7.26873	.15540	6.43484	.17333	5.76937	10
51	.10246	9.76009	.12013	8.32446	.13787	7.25310	.15570	6.42253	.17363	5.75941	9
52	.10275	9.73217	.12042	8.30406	.13817	7.23754	.15600	6.41026	.17393	5.74949	8
53	.10305	9.70441	.12072	8.28376	.13846	7.22204	.15630	6.39804	.17423	5.73960	7
54	.10334	9.67680	.12101	8.26355	.13876	7.20661	.15660	6.38587	.17453	5.72974	6
55	.10363	9.64935	.12131	8.24345	.13906	7.19125	.15689	6.37374	.17483	5.71992	5
56	.10393	9.62205	.12160	8.22344	.13935	7.17594	.15719	6.36165	.17513	5.71013	4
57	.10422	9.59490	.12190	8.20352	.13965	7.16071	.15749	6.34961	.17543	5.70037	3
58	.10452	9.56791	.12219	8.18370	.13995	7.14553	.15779	6.33761	.17573	5.69064	2
59	.10481	9.54106	.12249	8.16398	.14024	7.13042	.15809	6.32566	.17603	5.68094	1
60	.10510	9.51436	.12278	8.14435	.14054	7.11537	.15838	6.31375	.17633	5.67128	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
′	84°		83°		82°		81°		80°		′

NATURAL TANGENTS AND COTANGENTS

′	10°		11°		12°		13°		14°		′
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.17633	5.67128	.19438	5.14455	.21256	4.70463	.23087	4.33148	.24933	4.01078	60
1	.17663	5.66165	.19468	5.13658	.21286	4.69791	.23117	4.32573	.24964	4.00582	59
2	.17693	5.65205	.19498	5.12862	.21316	4.69121	.23148	4.32001	.24995	4.00086	58
3	.17723	5.64248	.19529	5.12069	.21347	4.68452	.23179	4.31430	.25026	3.99592	57
4	.17753	5.63295	.19559	5.11279	.21377	4.67786	.23209	4.30860	.25056	3.99099	56
5	.17783	5.62344	.19589	5.10490	.21408	4.67121	.23240	4.30291	.25087	3.98607	55
6	.17813	5.61397	.19619	5.09704	.21438	4.66458	.23271	4.29724	.25118	3.98117	54
7	.17843	5.60452	.19649	5.08921	.21469	4.65797	.23301	4.29159	.25149	3.97627	53
8	.17873	5.59511	.19680	5.08139	.21499	4.65138	.23332	4.28595	.25180	3.97139	52
9	.17903	5.58573	.19710	5.07360	.21529	4.64480	.23363	4.28032	.25211	3.96651	51
10	.17933	5.57638	.19740	5.06584	.21560	4.63825	.23393	4.27471	.25242	3.96165	50
11	.17963	5.56706	.19770	5.05809	.21590	4.63171	.23424	4.26911	.25273	3.95680	49
12	.17993	5.55777	.19801	5.05037	.21621	4.62518	.23455	4.26352	.25304	3.95196	48
13	.18023	5.54851	.19831	5.04267	.21651	4.61868	.23485	4.25795	.25335	3.94713	47
14	.18053	5.53927	.19861	5.03499	.21682	4.61219	.23516	4.25239	.25366	3.94232	46
15	.18083	5.53007	.19891	5.02734	.21712	4.60572	.23547	4.24685	.25397	3.93751	45
16	.18113	5.52090	.19921	5.01971	.21743	4.59927	.23578	4.24132	.25428	3.93271	44
17	.18143	5.51176	.19952	5.01210	.21773	4.59283	.23608	4.23580	.25459	3.92793	43
18	.18173	5.50264	.19982	5.00451	.21804	4.58641	.23639	4.23030	.25490	3.92316	42
19	.18203	5.49356	.20012	4.99695	.21834	4.58001	.23670	4.22481	.25521	3.91839	41
20	.18233	5.48451	.20042	4.98940	.21864	4.57363	.23700	4.21933	.25552	3.91364	40
21	.18263	5.47548	.20073	4.98188	.21895	4.56726	.23731	4.21387	.25583	3.90890	39
22	.18293	5.46648	.20103	4.97438	.21925	4.56091	.23762	4.20842	.25614	3.90417	38
23	.18323	5.45751	.20133	4.96690	.21956	4.55458	.23793	4.20298	.25645	3.89945	37
24	.18353	5.44857	.20164	4.95945	.21986	4.54826	.23823	4.19756	.25676	3.89474	36
25	.18384	5.43966	.20194	4.95201	.22017	4.54196	.23854	4.19215	.25707	3.89004	35
26	.18414	5.43077	.20224	4.94460	.22047	4.53568	.23885	4.18675	.25738	3.88536	34
27	.18444	5.42192	.20254	4.93721	.22078	4.52941	.23916	4.18137	.25769	3.88068	33
28	.18474	5.41309	.20285	4.92984	.22108	4.52316	.23946	4.17600	.25800	3.87601	32
29	.18504	5.40429	.20315	4.92249	.22139	4.51693	.23977	4.17064	.25831	3.87136	31
30	.18534	5.39552	.20345	4.91516	.22169	4.51071	.24008	4.16530	.25862	3.86671	30
31	.18564	5.38677	.20376	4.90785	.22200	4.50451	.24039	4.15997	.25893	3.86208	29
32	.18594	5.37805	.20406	4.90056	.22231	4.49832	.24069	4.15465	.25924	3.85745	28
33	.18624	5.36936	.20436	4.89330	.22261	4.49215	.24100	4.14934	.25955	3.85284	27
34	.18654	5.36070	.20466	4.88605	.22292	4.48600	.24131	4.14405	.25986	3.84824	26
35	.18684	5.35206	.20497	4.87882	.22322	4.47986	.24162	4.13877	.26017	3.84364	25
36	.18714	5.34345	.20527	4.87162	.22353	4.47374	.24193	4.13350	.26048	3.83906	24
37	.18745	5.33487	.20557	4.86444	.22383	4.46764	.24223	4.12825	.26079	3.83449	23
38	.18775	5.32631	.20588	4.85727	.22414	4.46155	.24254	4.12301	.26110	3.82992	22
39	.18805	5.31778	.20618	4.85013	.22444	4.45548	.24285	4.11778	.26141	3.82537	21
40	.18835	5.30928	.20648	4.84300	.22475	4.44942	.24316	4.11256	.26172	3.82083	20
41	.18865	5.30080	.20679	4.83590	.22505	4.44338	.24347	4.10736	.26203	3.81630	19
42	.18895	5.29235	.20709	4.82882	.22536	4.43735	.24377	4.10216	.26235	3.81177	18
43	.18925	5.28393	.20739	4.82175	.22567	4.43134	.24408	4.09699	.26266	3.80726	17
44	.18955	5.27553	.20770	4.81471	.22597	4.42534	.24439	4.09182	.26297	3.80276	16
45	.18986	5.26715	.20800	4.80769	.22628	4.41936	.24470	4.08666	.26328	3.79827	15
46	.19016	5.25880	.20830	4.80068	.22658	4.41340	.24501	4.08152	.26359	3.79378	14
47	.19046	5.25048	.20861	4.79370	.22689	4.40745	.24532	4.07639	.26390	3.78931	13
48	.19076	5.24218	.20891	4.78673	.22719	4.40152	.24562	4.07127	.26421	3.78485	12
49	.19106	5.23391	.20921	4.77978	.22750	4.39560	.24593	4.06616	.26452	3.78040	11
50	.19136	5.22566	.20952	4.77286	.22781	4.38969	.24624	4.06107	.26483	3.77595	10
51	.19166	5.21744	.20982	4.76595	.22811	4.38381	.24655	4.05599	.26515	3.77152	9
52	.19197	5.20925	.21013	4.75906	.22842	4.37793	.24686	4.05092	.26546	3.76709	8
53	.19227	5.20107	.21043	4.75219	.22872	4.37207	.24717	4.04586	.26577	3.76268	7
54	.19257	5.19293	.21073	4.74534	.22903	4.36623	.24747	4.04081	.26608	3.75828	6
55	.19287	5.18480	.21104	4.73851	.22934	4.36040	.24778	4.03578	.26639	3.75388	5
56	.19317	5.17671	.21134	4.73170	.22964	4.35459	.24809	4.03076	.26670	3.74950	4
57	.19347	5.16863	.21164	4.72490	.22995	4.34879	.24840	4.02574	.26701	3.74512	3
58	.19378	5.16058	.21195	4.71813	.23026	4.34300	.24871	4.02074	.26733	3.74075	2
59	.19408	5.15256	.21225	4.71137	.23056	4.33723	.24902	4.01576	.26764	3.73640	1
60	.19438	5.14455	.21256	4.70463	.23087	4.33148	.24933	4.01078	.26795	3.73205	0
′	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	′
	79°		78°		77°		76°		75°		

NATURAL TANGENTS AND COTANGENTS

′	15°		16°		17°		18°		19°		′
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.26795	3.73205	.28675	3.48741	.30573	3.27085	.32492	3.07768	.34433	2.90421	60
1	.26826	3.72771	.28706	3.48359	.30605	3.26745	.32524	3.07464	.34465	2.90147	59
2	.26857	3.72338	.28738	3.47977	.30637	3.26406	.32556	3.07160	.34498	2.89873	58
3	.26888	3.71907	.28769	3.47596	.30669	3.26067	.32588	3.06857	.34530	2.89600	57
4	.26920	3.71476	.28800	3.47216	.30700	3.25729	.32621	3.06554	.34563	2.89327	56
5	.26951	3.71046	.28832	3.46837	.30732	3.25392	.32653	3.06252	.34596	2.89055	55
6	.26982	3.70616	.28864	3.46458	.30764	3.25055	.32685	3.05950	.34628	2.88783	54
7	.27013	3.70188	.28895	3.46080	.30796	3.24719	.32717	3.05649	.34661	2.88511	53
8	.27044	3.69761	.28927	3.45703	.30828	3.24383	.32749	3.05349	.34693	2.88240	52
9	.27076	3.69335	.28958	3.45327	.30860	3.24049	.32782	3.05049	.34726	2.87970	51
10	.27107	3.68909	.28990	3.44951	.30891	3.23714	.32814	3.04749	.34758	2.87700	50
11	.27138	3.68485	.29021	3.44576	.30923	3.23381	.32846	3.04450	.34791	2.87430	49
12	.27169	3.68061	.29053	3.44202	.30955	3.23048	.32878	3.04152	.34824	2.87161	48
13	.27201	3.67638	.29084	3.43829	.30987	3.22715	.32911	3.03854	.34856	2.86892	47
14	.27232	3.67217	.29116	3.43456	.31019	3.22384	.32943	3.03556	.34889	2.86624	46
15	.27263	3.66796	.29147	3.43084	.31051	3.22053	.32975	3.03260	.34922	2.86356	45
16	.27294	3.66376	.29179	3.42713	.31083	3.21722	.33007	3.02963	.34954	2.86089	44
17	.27326	3.65957	.29210	3.42343	.31115	3.21392	.33040	3.02667	.34987	2.85822	43
18	.27357	3.65538	.29242	3.41973	.31147	3.21063	.33072	3.02372	.35020	2.85555	42
19	.27388	3.65121	.29274	3.41604	.31178	3.20734	.33104	3.02077	.35052	2.85289	41
20	.27419	3.64705	.29305	3.41236	.31210	3.20406	.33136	3.01783	.35085	2.85023	40
21	.27451	3.64289	.29337	3.40869	.31242	3.20079	.33169	3.01489	.35118	2.84758	39
22	.27482	3.63874	.29368	3.40502	.31274	3.19752	.33201	3.01196	.35150	2.84494	38
23	.27513	3.63461	.29400	3.40136	.31306	3.19426	.33233	3.00903	.35183	2.84229	37
24	.27545	3.63048	.29432	3.39771	.31338	3.19100	.33266	3.00611	.35216	2.83965	36
25	.27576	3.62636	.29463	3.39406	.31370	3.18775	.33298	3.00319	.35248	2.83702	35
26	.27607	3.62224	.29495	3.39042	.31402	3.18451	.33330	3.00028	.35281	2.83439	34
27	.27638	3.61814	.29526	3.38679	.31434	3.18127	.33363	2.99738	.35314	2.83176	33
28	.27670	3.61405	.29558	3.38317	.31466	3.17804	.33395	2.99447	.35346	2.82914	32
29	.27701	3.60996	.29590	3.37955	.31498	3.17481	.33427	2.99158	.35379	2.82653	31
30	.27732	3.60588	.29621	3.37594	.31530	3.17159	.33460	2.98868	.35412	2.82391	30
31	.27764	3.60181	.29653	3.37234	.31562	3.16838	.33492	2.98580	.35445	2.82130	29
32	.27795	3.59775	.29685	3.36875	.31594	3.16517	.33524	2.98292	.35477	2.81870	28
33	.27826	3.59370	.29716	3.36516	.31626	3.16197	.33557	2.98004	.35510	2.81610	27
34	.27858	3.58966	.29748	3.36158	.31658	3.15877	.33589	2.97717	.35543	2.81350	26
35	.27889	3.58562	.29780	3.35800	.31690	3.15558	.33621	2.97430	.35576	2.81091	25
36	.27921	3.58160	.29811	3.35443	.31722	3.15240	.33654	2.97144	.35608	2.80833	24
37	.27952	3.57758	.29843	3.35087	.31754	3.14922	.33686	2.96858	.35641	2.80574	23
38	.27983	3.57357	.29875	3.34732	.31786	3.14605	.33718	2.96573	.35674	2.80316	22
39	.28015	3.56957	.29906	3.34377	.31818	3.14288	.33751	2.96288	.35707	2.80059	21
40	.28046	3.56557	.29938	3.34023	.31850	3.13972	.33783	2.96004	.35740	2.79802	20
41	.28077	3.56159	.29970	3.33670	.31882	3.13656	.33816	2.95721	.35772	2.79545	19
42	.28109	3.55761	.30001	3.33317	.31914	3.13341	.33848	2.95437	.35805	2.79289	18
43	.28140	3.55364	.30033	3.32965	.31946	3.13027	.33881	2.95155	.35838	2.79033	17
44	.28172	3.54968	.30065	3.32614	.31978	3.12713	.33913	2.94872	.35871	2.78778	16
45	.28203	3.54573	.30097	3.32264	.32010	3.12400	.33945	2.94591	.35904	2.78523	15
46	.28234	3.54179	.30128	3.31914	.32042	3.12087	.33978	2.94309	.35937	2.78269	14
47	.28266	3.53785	.30160	3.31565	.32074	3.11775	.34010	2.94028	.35969	2.78014	13
48	.28297	3.53393	.30192	3.31216	.32106	3.11464	.34043	2.93748	.36002	2.77761	12
49	.28329	3.53001	.30224	3.30868	.32139	3.11153	.34075	2.93468	.36035	2.77507	11
50	.28360	3.52609	.30255	3.30521	.32171	3.10842	.34108	2.93189	.36068	2.77254	10
51	.28391	3.52219	.30287	3.30174	.32203	3.10532	.34140	2.92910	.36101	2.77002	9
52	.28423	3.51829	.30319	3.29829	.32235	3.10223	.34173	2.92632	.36134	2.76750	8
53	.28454	3.51441	.30351	3.29483	.32267	3.09914	.34205	2.92354	.36167	2.76498	7
54	.28486	3.51053	.30382	3.29139	.32299	3.09606	.34238	2.92076	.36199	2.76247	6
55	.28517	3.50666	.30414	3.28795	.32331	3.09298	.34270	2.91799	.36232	2.75996	5
56	.28549	3.50279	.30446	3.28452	.32363	3.08991	.34303	2.91523	.36265	2.75746	4
57	.28580	3.49894	.30478	3.28109	.32396	3.08685	.34335	2.91246	.36298	2.75496	3
58	.28612	3.49509	.30509	3.27767	.32428	3.08379	.34368	2.90971	.36331	2.75246	2
59	.28643	3.49125	.30541	3.27426	.32460	3.08073	.34400	2.90696	.36364	2.74997	1
60	.28675	3.48741	.30573	3.27085	.32492	3.07768	.34433	2.90421	.36397	2.74748	0
′	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	′
	74°		73°		72°		71°		70°		

NATURAL TANGENTS AND COTANGENTS

′	20°		21°		22°		23°		24°		′
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.36397	2.74748	.38386	2.60509	.40403	2.47509	.42447	2.35585	.44523	2.24604	60
1	.36430	2.74499	.38420	2.60283	.40436	2.47302	.42482	2.35395	.44558	2.24428	59
2	.36463	2.74251	.38453	2.60057	.40470	2.47095	.42516	2.35205	.44593	2.24252	58
3	.36496	2.74004	.38487	2.59831	.40504	2.46888	.42551	2.35015	.44627	2.24077	57
4	.36529	2.73756	.38520	2.59606	.40538	2.46682	.42585	2.34825	.44662	2.23902	56
5	.36562	2.73509	.38553	2.59381	.40572	2.46476	.42619	2.34636	.44697	2.23727	55
6	.36595	2.73263	.38587	2.59156	.40606	2.46270	.42654	2.34447	.44732	2.23553	54
7	.36628	2.73017	.38620	2.58932	.40640	2.46065	.42688	2.34258	.44767	2.23378	53
8	.36661	2.72771	.38654	2.58708	.40674	2.45860	.42722	2.34069	.44802	2.23204	52
9	.36694	2.72526	.38687	2.58484	.40707	2.45655	.42757	2.33881	.44837	2.23030	51
10	.36727	2.72281	.38721	2.58261	.40741	2.45451	.42791	2.33693	.44872	2.22857	50
11	.36760	2.72036	.38754	2.58038	.40775	2.45246	.42826	2.33505	.44907	2.22683	49
12	.36793	2.71792	.38787	2.57815	.40809	2.45043	.42860	2.33317	.44942	2.22510	48
13	.36826	2.71548	.38821	2.57593	.40843	2.44839	.42894	2.33130	.44977	2.22337	47
14	.36859	2.71305	.38854	2.57371	.40877	2.44636	.42929	2.32943	.45012	2.22164	46
15	.36892	2.71062	.38888	2.57150	.40911	2.44433	.42963	2.32756	.45047	2.21992	45
16	.36925	2.70819	.38921	2.56928	.40945	2.44230	.42998	2.32570	.45082	2.21819	44
17	.36958	2.70577	.38955	2.56707	.40979	2.44027	.43032	2.32383	.45117	2.21647	43
18	.36991	2.70335	.38988	2.56487	.41013	2.43825	.43067	2.32197	.45152	2.21475	42
19	.37024	2.70094	.39022	2.56266	.41047	2.43623	.43101	2.32012	.45187	2.21304	41
20	.37057	2.69853	.39055	2.56046	.41081	2.43422	.43136	2.31826	.45222	2.21132	40
21	.37090	2.69612	.39089	2.55827	.41115	2.43220	.43170	2.31641	.45257	2.20961	39
22	.37123	2.69371	.39122	2.55608	.41149	2.43019	.43205	2.31456	.45292	2.20790	38
23	.37157	2.69131	.39156	2.55389	.41183	2.42819	.43230	2.31271	.45327	2.20619	37
24	.37190	2.68892	.39190	2.55170	.41217	2.42618	.43274	2.31086	.45362	2.20449	36
25	.37223	2.68653	.39223	2.54952	.41251	2.42418	.43308	2.30902	.45397	2.20278	35
26	.37256	2.68414	.39257	2.54734	.41285	2.42218	.43343	2.30718	.45432	2.20108	34
27	.37289	2.68175	.39290	2.54516	.41319	2.42019	.43378	2.30534	.45467	2.19938	33
28	.37322	2.67937	.39324	2.54299	.41353	2.41819	.43412	2.30351	.45502	2.19769	32
29	.37355	3.67700	.39357	2.54082	.41387	2.41620	.43447	2.30167	.45538	2.19599	31
30	.37388	2.67462	.39391	2.53865	.41421	2.41421	.43481	2.29984	.45573	2.19430	30
31	.37422	2.67225	.39425	2.53648	.41455	2.41223	.43516	2.29801	.45608	2.19261	29
32	.37455	2.66989	.39458	2.53432	.41490	2.41025	.43550	2.29619	.45643	2.19092	28
33	.37488	2.66752	.39492	2.53217	.41524	2.40827	.43585	2.29437	.45678	2.18923	27
34	.37521	2.66516	.39526	2.53001	.41558	2.40629	.43620	2.29254	.45713	2.18755	26
35	.37554	2.66281	.39559	2.52786	.41592	2.40432	.43654	2.29073	.45748	2.18587	25
36	.37588	2.66046	.39593	2.52571	.41626	2.40235	.43689	2.28891	.45784	2.18419	24
37	.37621	2.65811	.39626	2.52357	.41660	2.40038	.43724	2.28710	.45819	2.18251	23
38	.37654	2.65576	.39660	2.52142	.41694	2.39841	.43758	2.28528	.45854	2.18084	22
39	.37687	2.65342	.39694	2.51929	.41728	2.39645	.43793	2.28348	.45889	2.17916	21
40	.37720	2.65109	.39727	2.51715	.41763	2.39449	.43828	2.28167	.45924	2.17749	20
41	.37754	2.64875	.39761	2.51502	.41797	2.39253	.43862	2.27987	.45960	2.17582	19
42	.37787	2.64642	.39795	2.51289	.41831	2.39058	.43897	2.27806	.45995	2.17416	18
43	.37820	2.64410	.39829	2.51076	.41865	2.38863	.43932	2.27626	.46030	2.17249	17
44	.37853	2.64177	.39862	2.50864	.41899	2.38668	.43966	2.27447	.46065	2.17083	16
45	.37887	2.63945	.39896	2.50652	.41933	2.38473	.44001	2.27267	.46101	2.16917	15
46	.37920	2.63714	.39930	2.50440	.41968	2.38279	.44036	2.27088	.46136	2.16751	14
47	.37953	2.63483	.39963	2.50229	.42002	2.38084	.44071	2.26909	.46171	2.16585	13
48	.37986	2.63252	.39997	2.50018	.42036	2.37891	.44105	2.26730	.46206	2.16420	12
49	.38020	2.63021	.40031	2.49807	.42070	2.37697	.44140	2.26552	.46242	2.16255	11
50	.38053	2.62791	.40065	2.49597	.42105	2.37504	.44175	2.26374	.46277	2.16090	10
51	.38086	2.62561	.40098	2.49386	.42139	2.37311	.44210	2.26196	.46312	2.15925	9
52	.38120	2.62332	.40132	2.49177	.42173	2.37118	.44244	2.26018	.46348	2.15760	8
53	.38153	2.62103	.40166	2.48967	.42207	2.36925	.44279	2.25840	.46383	2.15596	7
54	.38186	2.61874	.40200	2.48758	.42242	2.36733	.44314	2.25663	.46418	2.15432	6
55	.38220	2.61646	.40234	2.48549	.42276	2.36541	.44349	2.25486	.46454	2.15268	5
56	.38253	2.61418	.40267	2.48340	.42310	2.36349	.44384	2.25309	.46489	2.15104	4
57	.38286	2.61190	.40301	2.48132	.42345	2.36158	.44418	2.25132	.46525	2.14940	3
58	.38320	2.60963	.40335	2.47924	.42379	2.35967	.44453	2.24956	.46560	2.14777	2
59	.38353	2.60736	.40369	2.47716	.42413	2.35776	.44488	2.24780	.46595	2.14614	1
60	.38386	2.60509	.40403	2.47509	.42447	2.35585	.44523	2.24604	.46631	2.14451	0
′	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	′
	69°		68°		67°		66°		65°		

NATURAL TANGENTS AND COTANGENTS

′	25°		26°		27°		28°		29°		′
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.46631	2.14451	.48773	2.05030	.50953	1.96261	.53171	1.88073	.55431	1.80405	60
1	.46666	2.14288	.48809	2.04879	.50989	1.96120	.53208	1.87941	.55469	1.80281	59
2	.46702	2.14125	.48845	2.04728	.51026	1.95979	.53246	1.87809	.55507	1.80158	58
3	.46737	2.13963	.48881	2.04577	.51063	1.95838	.53283	1.87677	.55545	1.80034	57
4	.46772	2.13801	.48917	2.04426	.51099	1.95698	.53320	1.87546	.55583	1.79911	56
5	.46808	2.13639	.48953	2.04276	.51136	1.95557	.53358	1.87415	.55621	1.79788	55
6	.46843	2.13477	.48989	2.04125	.51173	1.95417	.53395	1.87283	.55659	1.79665	54
7	.46879	2.13316	.49026	2.03975	.51209	1.95277	.53432	1.87152	.55697	1.79542	53
8	.46914	2.13154	.49062	2.03825	.51246	1.95137	.53470	1.87021	.55736	1.79419	52
9	.46950	2.12993	.49098	2.03675	.51283	1.94997	.53507	1.86891	.55774	1.79296	51
10	.46985	2.12832	.49134	2.03526	.51319	1.94858	.53545	1.86760	.55812	1.79174	50
11	.47021	2.12671	.49170	2.03376	.51356	1.94718	.53582	1.86630	.55850	1.79051	49
12	.47056	2.12511	.49206	2.03227	.51393	1.94579	.53620	1.86499	.55888	1.78929	48
13	.47092	2.12350	.49242	2.03078	.51430	1.94440	.53657	1.86369	.55926	1.78807	47
14	.47128	2.12190	.49278	2.02929	.51467	1.94301	.53694	1.86239	.55964	1.78685	46
15	.47163	2.12030	.49315	2.02780	.51503	1.94162	.53732	1.86109	.56003	1.78563	45
16	.47199	2.11871	.49351	2.02631	.51540	1.94023	.53769	1.85979	.56041	1.78441	44
17	.47234	2.11711	.49387	2.02483	.51577	1.93885	.53807	1.85850	.56079	1.78319	43
18	.47270	2.11552	.49423	2.02335	.51614	1.93746	.53844	1.85720	.56117	1.73198	42
19	.47305	2.11392	.49459	2.02187	.51651	1.93608	.53882	1.85591	.56156	1.78077	41
20	.47341	2.11233	.49495	2.02039	.51688	1.93470	.53920	1.85462	.56194	1.77955	40
21	.47377	2.11075	.49532	2.01891	.51724	1.93332	.53957	1.85333	.56232	1.77834	39
22	.47412	2.10916	.49568	2.01743	.51761	1.93195	.53995	1.85204	.56270	1.77713	38
23	.47448	2.10758	.49604	2.01596	.51798	1.93057	.54032	1.85075	.56309	1.77592	37
24	.47483	2.10600	.49640	2.01449	.51835	1.92920	.54070	1.84946	.56347	1.77471	36
25	.47519	2.10442	.49677	2.01302	.51872	1.92782	.54107	1.84818	.56385	1.77351	35
26	.47555	2.10284	.49713	2.01155	.51909	1.92645	.54145	1.84689	.56424	1.77230	34
27	.47590	2.10126	.49749	2.01008	.51946	1.92508	.54183	1.84561	.56462	1.77110	33
28	.47626	2.09969	.49786	2.00862	.51983	1.92371	.54220	1.84433	.56501	1.76990	32
29	.47662	2.09811	.49822	2.00715	.52020	1.92235	.54258	1.84305	.56539	1.76869	31
30	.47698	2.09654	.49858	2.00569	.52057	1.92098	.54296	1.84177	.56577	1.76749	30
31	.47733	2.09498	.49894	2.00423	.52094	1.91962	.54333	1.84049	.56616	1.76629	29
32	.47769	2.09341	.49931	2.00277	.52131	1.91826	.54371	1.83922	.56654	1.76510	28
33	.47805	2.09184	.49967	2.00131	.52168	1.91690	.54409	1.83794	.56693	1.76390	27
34	.47840	2.09028	.50004	1.99986	.52205	1.91554	.54446	1.83667	.56731	1.76271	26
35	.47876	2.08873	.50040	1.99841	.52242	1.91418	.54484	1.83540	.56769	1.76151	25
36	.47912	2.08716	.50076	1.99695	.52279	1.91282	.54522	1.83413	.56808	1.76032	24
37	.47948	2.08560	.50113	1.99550	.52316	1.91147	.54560	1.83286	.56846	1.75913	23
38	.47984	2.08405	.50149	1.99406	.52353	1.91012	.54597	1.83159	.56885	1.75794	22
39	.48019	2.08250	.50185	1.99261	.52390	1.90876	.54635	1.83033	.56923	1.75675	21
40	.48055	2.08094	.50222	1.99116	.52427	1.90741	.54673	1.82906	.56962	1.75556	20
41	.48091	2.07939	.50258	1.98972	.52464	1.90607	.54711	1.82780	.57000	1.75437	19
42	.48127	2.07785	.50295	1.98828	.52501	1.90472	.54748	1.82654	.57039	1.75319	18
43	.48163	2.07630	.50331	1.98684	.52538	1.90337	.54786	1.82528	.57078	1.75200	17
44	.48198	2.07476	.50368	1.98540	.52575	1.90203	.54824	1.82402	.57116	1.75082	16
45	.48234	2.07321	.50404	1.98396	.52613	1.90069	.54862	1.82276	.57155	1.74964	15
46	.48270	2.07167	.50441	1.98253	.52650	1.89935	.54900	1.82150	.57193	1.74846	14
47	.48306	2.07014	.50477	1.98110	.52687	1.89801	.54938	1.82025	.57232	1.74728	13
48	.48342	2.06860	.50514	1.97966	.52724	1.89667	.54975	1.81899	.57271	1.74610	12
49	.48378	2.06706	.50550	1.97823	.52761	1.89533	.55013	1.81774	.57309	1.74492	11
50	.48414	2.06553	.50587	1.97681	.52798	1.89400	.55051	1.81649	.57348	1.74375	10
51	.48450	2.06400	.50623	1.97538	.52836	1.89266	.55089	1.81524	.57386	1.74257	9
52	.48486	2.06247	.50660	1.97395	.52873	1.89133	.55127	1.81399	.57425	1.74140	8
53	.48521	2.06094	.50696	1.97253	.52910	1.89000	.55165	1.81274	.57464	1.74022	7
54	.48557	2.05942	.50733	1.97111	.52947	1.88867	.55203	1.81150	.57503	1.73905	6
55	.48593	2.05790	.50769	1.96969	.52985	1.88734	.55241	1.81025	.57541	1.73788	5
56	.48629	2.05637	.50806	1.96827	.53022	1.88603	.55279	1.80901	.57580	1.73671	4
57	.48665	2.05485	.50843	1.96685	.53059	1.88469	.55317	1.80777	.57619	1.73555	3
58	.48701	2.05333	.50879	1.96544	.53096	1.88337	.55355	1.80653	.57657	1.73438	2
59	.48737	2.05182	.50916	1.96402	.53134	1.88205	.55393	1.80529	.57696	1.73321	1
60	.48773	2.05030	.50953	1.96261	.53171	1.88073	.55431	1.80405	.57735	1.73205	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
′	64°		63°		62°		61°		60°		

NATURAL TANGENTS AND COTANGENTS

′	30°		31°		32°		33°		34°		′
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.57735	1.73205	.60086	1.66428	.62487	1.60033	.64941	1.53986	.67451	1.48256	60
1	.57774	1.73089	.60126	1.66318	.62527	1.59930	.64982	1.53888	.67493	1.48163	59
2	.57813	1.72973	.60165	1.66209	.62568	1.59826	.65024	1.53791	.67536	1.48070	58
3	.57851	1.72857	.60205	1.66099	.62608	1.59723	.65065	1.53693	.67578	1.47977	57
4	.57890	1.72741	.60245	1.65990	.62649	1.59620	.65106	1.53595	.67620	1.47885	56
5	.57929	1.72625	.60284	1.65881	.62689	1.59517	.65148	1.53497	.67663	1.47792	55
6	.57968	1.72509	.60324	1.65772	.62730	1.59414	.65189	1.53400	.67705	1.47699	54
7	.58007	1.72393	.60364	1.65663	.62770	1.59311	.65231	1.53302	.67748	1.47607	53
8	.58046	1.72278	.60403	1.65554	.62811	1.59208	.65272	1.53205	.67790	1.47514	52
9	.58085	1.72163	.60443	1.65445	.62852	1.59105	.65314	1.53107	.67832	1.47422	51
10	.58124	1.72047	.60483	1.65337	.62892	1.59002	.65355	1.53010	.67875	1.47330	50
11	.58162	1.71932	.60522	1.65228	.62933	1.58900	.65397	1.52913	.67917	1.47238	49
12	.58201	1.71817	.60562	1.65120	.62973	1.58797	.65438	1.52816	.67960	1.47146	48
13	.58240	1.71702	.60602	1.65011	.63014	1.58695	.65480	1.52719	.68002	1.47053	47
14	.58279	1.71588	.60642	1.64903	.63055	1.58593	.65521	1.52622	.68045	1.46962	46
15	.58318	1.71473	.60681	1.64795	.63095	1.58490	.65563	1.52525	.68088	1.46870	45
16	.58357	1.71358	.60721	1.64687	.63136	1.58388	.65604	1.52429	.68130	1.46778	44
17	.58396	1.71244	.60761	1.64579	.63177	1.58286	.65646	1.52332	.68173	1.46686	43
18	.58435	1.71129	.60801	1.64471	.63217	1.58184	.65688	1.52235	.68215	1.46595	42
19	.58474	1.71015	.60841	1.64363	.63258	1.58083	.65729	1.52139	.68258	1.46503	41
20	.58513	1.70901	.60881	1.64256	.63299	1.57981	.65771	1.52043	.68301	1.46411	40
21	.58552	1.70787	.60921	1.64148	.63340	1.57879	.65813	1.51946	.68343	1.46320	39
22	.58591	1.70673	.60960	1.64041	.63380	1.57778	.65854	1.51850	.68386	1.46229	38
23	.58631	1.70560	.61000	1.63934	.63421	1.57676	.65896	1.51754	.68429	1.46137	37
24	.58670	1.70446	.61040	1.63826	.63462	1.57575	.65938	1.51658	.68471	1.46046	36
25	.58709	1.70332	.61080	1.63719	.63503	1.57474	.65980	1.51562	.68514	1.45955	35
26	.58748	1.70219	.61120	1.63612	.63544	1.57372	.66021	1.51466	.68557	1.45864	34
27	.58787	1.70106	.61160	1.63505	.63584	1.57271	.66063	1.51370	.68600	1.45773	33
28	.58826	1.69992	.61200	1.63398	.63625	1.57170	.66105	1.51275	.68642	1.45682	32
29	.58865	1.69879	.61240	1.63292	.63666	1.57069	.66147	1.51179	.68685	1.45592	31
30	.58905	1.69766	.61280	1.63185	.63707	1.56969	.66189	1.51084	.68728	1.45501	30
31	.58944	1.69653	.61320	1.63079	.63748	1.56868	.66230	1.50988	.68771	1.45410	29
32	.58983	1.69541	.61360	1.62972	.63789	1.56767	.66272	1.50893	.68814	1.45320	28
33	.59022	1.69428	.61400	1.62866	.63830	1.56667	.66314	1.50797	.68857	1.45229	27
34	.59061	1.69316	.61440	1.62760	.63871	1.56566	.66356	1.50702	.68900	1.45139	26
35	.59101	1.69203	.61480	1.62654	.63912	1.56466	.66398	1.50607	.68942	1.45049	25
36	.59149	1.69091	.61520	1.62548	.63953	1.56366	.66440	1.50512	.68985	1.44958	24
37	.59179	1.68979	.61561	1.62442	.63994	1.56265	.66482	1.50417	.69028	1.44868	23
38	.59218	1.68866	.61601	1.62336	.64035	1.56165	.66524	1.50322	.69071	1.44778	22
39	.59258	1.68754	.61641	1.62230	.64076	1.56065	.66566	1.50228	.69114	1.44688	21
40	.59297	1.68643	.61681	1.62125	.64117	1.55966	.66608	1.50133	.69157	1.44598	20
41	.59336	1.68531	.61721	1.62019	.64158	1.55866	.66650	1.50038	.69200	1.44508	19
42	.59376	1.68419	.61761	1.61914	.64199	1.55766	.66692	1.49944	.69243	1.44418	18
43	.59415	1.68308	.61801	1.61808	.64240	1.55666	.66734	1.49849	.69286	1.44329	17
44	.59454	1.68196	.61842	1.61703	.64281	1.55567	.66776	1.49755	.69329	1.44239	16
45	.59494	1.68085	.61882	1.61598	.64322	1.55467	.66818	1.49661	.69372	1.44149	15
46	.59533	1.67974	.61922	1.61493	.64363	1.55368	.66860	1.49566	.69416	1.44060	14
47	.59573	1.67863	.61962	1.61388	.64404	1.55269	.66902	1.49472	.69459	1.43970	13
48	.59612	1.67752	.62003	1.61283	.64446	1.55170	.66944	1.49378	.69502	1.43881	12
49	.59651	1.67641	.62043	1.61179	.64487	1.55071	.66986	1.49284	.69545	1.43792	11
50	.59691	1.67530	.62083	1.61074	.64528	1.54972	.67028	1.49190	.69588	1.43703	10
51	.59730	1.67419	.62124	1.60970	.64569	1.54873	.67071	1.49097	.69631	1.43614	9
52	.59770	1.67309	.62164	1.60865	.64610	1.54774	.67113	1.49003	.69675	1.43525	8
53	.59809	1.67198	.62204	1.60761	.64652	1.54675	.67155	1.48909	.69718	1.43436	7
54	.59849	1.67088	.62245	1.60657	.64693	1.54576	.67197	1.48816	.69761	1.43347	6
55	.59888	1.66978	.62285	1.60553	.64734	1.54478	.67239	1.48722	.69804	1.43258	5
56	.59928	1.66867	.62325	1.60449	.64775	1.54379	.67282	1.48629	.69847	1.43169	4
57	.59967	1.66757	.62366	1.60345	.64817	1.54281	.67324	1.48536	.69891	1.43080	3
58	.60007	1.66647	.62406	1.60241	.64858	1.54183	.67366	1.48442	.69934	1.42992	2
59	.60046	1.66538	.62446	1.60137	.64899	1.54085	.67409	1.48349	.69977	1.42903	1
60	.60086	1.66428	.62487	1.60033	.64941	1.53986	.67451	1.48256	.70021	1.42815	0
′	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	′
			58°		57°		56°		55°		

NATURAL TANGENTS AND COTANGENTS

′	35° Tang	35° Cotang	36° Tang	36° Cotang	37° Tang	37° Cotang	38° Tang	38° Cotang	39° Tang	39° Cotang	′
0	.70021	1.42815	.72654	1.37638	.75355	1.32704	.78129	1.27994	.80978	1.23490	60
1	.70064	1.42726	.72699	1.37554	.75401	1.32624	.78175	1.27917	.81027	1.23416	59
2	.70107	1.42638	.72743	1.37470	.75447	1.32544	.78222	1.27841	.81075	1.23343	58
3	.70151	1.42550	.72788	1.37386	.75492	1.32464	.78269	1.27764	.81123	1.23270	57
4	.70194	1.42462	.72832	1.37302	.75538	1.32384	.78316	1.27688	.81171	1.23196	56
5	.70238	1.42374	.72877	1.37218	.75584	1.32304	.78363	1.27611	.81220	1.23123	55
6	.70281	1.42286	.72921	1.37134	.75629	1.32224	.78410	1.27535	.81268	1.23050	54
7	.70325	1.42198	.72966	1.37050	.75675	1.32144	.78457	1.27458	.81316	1.22977	53
8	.70368	1.42110	.73010	1.36967	.75721	1.32064	.78504	1.27382	.81364	1.22904	52
9	.70412	1.42022	.73055	1.36883	.75767	1.31984	.78551	1.27306	.81413	1.22831	51
10	.70455	1.41934	.73100	1.36800	.75812	1.31904	.78598	1.27230	.81461	1.22758	50
11	.70499	1.41847	.73144	1.36716	.75858	1.31825	.78645	1.27153	.81510	1.22685	49
12	.70542	1.41759	.73189	1.36633	.75904	1.31745	.78692	1.27077	.81558	1.22612	48
13	.70586	1.41672	.73234	1.36549	.75950	1.31666	.78739	1.27001	.81606	1.22539	47
14	.70629	1.41584	.73278	1.36466	.75996	1.31586	.78786	1.26925	.81655	1.22467	46
15	.70673	1.41497	.73323	1.36383	.76042	1.31507	.78834	1.26849	.81703	1.22394	45
16	.70717	1.41409	.73368	1.36300	.76088	1.31427	.78881	1.26774	.81752	1.22321	44
17	.70760	1.41322	.73413	1.36217	.76134	1.31348	.78928	1.26698	.81800	1.22249	43
18	.70804	1.41235	.73457	1.36134	.76180	1.31269	.78975	1.26622	.81849	1.22176	42
19	.70848	1.41148	.73502	1.36051	.76226	1.31190	.79022	1.26546	.81898	1.22104	41
20	.70891	1.41061	.73547	1.35968	.76272	1.31110	.79070	1.26471	.81946	1.22031	40
21	.70935	1.40974	.73592	1.35885	.76318	1.31031	.79117	1.26395	.81995	1.21959	39
22	.70979	1.40887	.73637	1.35802	.76364	1.30952	.79164	1.26319	.82044	1.21886	38
23	.71023	1.40800	.73681	1.35719	.76410	1.30873	.79212	1.26244	.82092	1.21814	37
24	.71066	1.40714	.73726	1.35637	.76456	1.30795	.79259	1.26169	.82141	1.21742	36
25	.71110	1.40627	.73771	1.35554	.76502	1.30716	.79306	1.26093	.82190	1.21670	35
26	.71154	1.40540	.73816	1.35472	.76548	1.30637	.79354	1.26018	.82238	1.21598	34
27	.71198	1.40454	.73861	1.35389	.76594	1.30558	.79401	1.25943	.82287	1.21526	33
28	.71242	1.40367	.73906	1.35307	.76640	1.30480	.79449	1.25867	.82336	1.21454	32
29	.71285	1.40281	.73951	1.35224	.76686	1.30401	.79496	1.25792	.82385	1.21382	31
30	.71329	1.40195	.73996	1.35142	.76733	1.30323	.79544	1.25717	.82434	1.21310	30
31	.71373	1.40109	.74041	1.35060	.76779	1.30244	.79591	1.25642	.82483	1.21238	29
32	.71417	1.40022	.74086	1.34978	.76825	1.30166	.79639	1.25567	.82531	1.21166	28
33	.71461	1.39936	.74131	1.34896	.76871	1.30087	.79686	1.25492	.82580	1.21094	27
34	.71505	1.39850	.74176	1.34814	.76918	1.30009	.79734	1.25417	.82629	1.21023	26
35	.71549	1.39764	.74221	1.34732	.76964	1.29931	.79781	1.25343	.82678	1.20951	25
36	.71593	1.39679	.74267	1.34650	.77010	1.29853	.79829	1.25268	.82727	1.20879	24
37	.71637	1.39593	.74312	1.34568	.77057	1.29775	.79877	1.25193	.82776	1.20808	23
38	.71681	1.39507	.74357	1.34487	.77103	1.29696	.79924	1.25118	.82825	1.20736	22
39	.71725	1.39421	.74402	1.34405	.77149	1.29618	.79972	1.25044	.82874	1.20665	21
40	.71769	1.39336	.74447	1.34323	.77196	1.29541	.80020	1.24969	.82923	1.20593	20
41	.71813	1.39250	.74492	1.34242	.77242	1.29463	.80067	1.24895	.82972	1.20522	19
42	.71857	1.39165	.74538	1.34160	.77289	1.29385	.80115	1.24820	.83022	1.20451	18
43	.71901	1.39079	.74583	1.34079	.77335	1.29307	.80163	1.24746	.83071	1.20379	17
44	.71946	1.38994	.74628	1.33998	.77382	1.29229	.80211	1.24672	.83120	1.20308	16
45	.71990	1.38909	.74674	1.33916	.77428	1.29152	.80258	1.24597	.83169	1.20237	15
46	.72034	1.38824	.74719	1.33835	.77475	1.29074	.80306	1.24523	.83218	1.20166	14
47	.72078	1.38738	.74764	1.33754	.77521	1.28997	.80354	1.24449	.83268	1.20095	13
48	.72122	1.38653	.74810	1.33673	.77568	1.28919	.80402	1.24375	.83317	1.20024	12
49	.72167	1.38568	.74855	1.33592	.77615	1.28842	.80450	1.24301	.83366	1.19953	11
50	.72211	1.38484	.74900	1.33511	.77661	1.28764	.80498	1.24227	.83415	1.19882	10
51	.72255	1.38399	.74946	1.33430	.77708	1.28687	.80546	1.24153	.83465	1.19811	9
52	.72299	1.38314	.74991	1.33349	.77754	1.28610	.80594	1.24079	.83514	1.19740	8
53	.72344	1.38229	.75037	1.33268	.77801	1.28533	.80642	1.24005	.83564	1.19669	7
54	.72388	1.38145	.75082	1.33187	.77848	1.28456	.80690	1.23931	.83613	1.19599	6
55	.72432	1.38060	.75128	1.33107	.77895	1.28379	.80738	1.23858	.83662	1.19528	5
56	.72477	1.37976	.75173	1.33026	.77941	1.28302	.80786	1.23784	.83712	1.19457	4
57	.72521	1.37891	.75219	1.32946	.77988	1.28225	.80834	1.23710	.83761	1.19387	3
58	.72565	1.37807	.75264	1.32865	.78035	1.28148	.80882	1.23637	.83811	1.19316	2
59	.72610	1.37722	.75310	1.32785	.78082	1.28071	.80930	1.23563	.83860	1.19246	1
60	.72654	1.37638	.75355	1.32704	.78129	1.27994	.80978	1.23490	.83910	1.19175	0
′	54° Cotang	54° Tang	53° Cotang	53° Tang	52° Cotang	52° Tang	51° Cotang	51° Tang	50° Cotang	50° Tang	′

NATURAL TANGENTS AND COTANGENTS

′	40° Tang	40° Cotang	41° Tang	41° Cotang	42° Tang	42° Cotang	43° Tang	43° Cotang	44° Tang	44° Cotang	′
0	.83910	1.19175	.86929	1.15037	.90040	1.11061	.93252	1.07237	.96569	1.03553	60
1	.83960	1.19105	.86980	1.14969	.90093	1.10996	.93306	1.07174	.96625	1.03493	59
2	.84009	1.19035	.87031	1.14902	.90146	1.10931	.93360	1.07112	.96681	1.03433	58
3	.84059	1.18964	.87082	1.14834	.90199	1.10867	.93415	1.07049	.96738	1.03372	57
4	.84108	1.18894	.87133	1.14767	.90251	1.10802	.93469	1.06987	.96794	1.03312	56
5	.84158	1.18824	.87184	1.14699	.90304	1.10737	.93524	1.06925	.96850	1.03252	55
6	.84208	1.18754	.87236	1.14632	.90357	1.10672	.93578	1.06862	.96907	1.03192	54
7	.84258	1.18684	.87287	1.14565	.90410	1.10607	.93633	1.06800	.96963	1.03132	53
8	.84307	1.18614	.87338	1.14498	.90463	1.10543	.93688	1.06738	.97020	1.03072	52
9	.84357	1.18544	.87389	1.14430	.90516	1.10478	.93742	1.06676	.97076	1.03012	51
10	.84407	1.18474	.87441	1.14363	.90569	1.10414	.93797	1.06613	.97133	1.02952	50
11	.84457	1.18404	.87492	1.14296	.90621	1.10349	.93852	1.06551	.97189	1.02892	49
12	.84507	1.18334	.87543	1.14229	.90674	1.10285	.93906	1.06489	.97246	1.02832	48
13	.84556	1.18264	.87595	1.14162	.90727	1.10220	.93961	1.06427	.97302	1.02772	47
14	.84606	1.18194	.87646	1.14095	.90781	1.10156	.94016	1.06365	.97359	1.02713	46
15	.84656	1.18125	.87698	1.14028	.90834	1.10091	.94071	1.06303	.97416	1.02653	45
16	.84706	1.18055	.87749	1.13961	.90887	1.10027	.94125	1.06241	.97472	1.02593	44
17	.84756	1.17986	.87801	1.13894	.90940	1.09963	.94180	1.06179	.97529	1.02533	43
18	.84806	1.17916	.87852	1.13828	.90993	1.09399	.94235	1.06117	.97586	1.02474	42
19	.84856	1.17846	.87904	1.13761	.91046	1.09834	.94290	1.06056	.97643	1.02414	41
20	.84906	1.17777	.87955	1.13694	.91099	1.09770	.94345	1.05994	.97700	1.02355	40
21	.84956	1.17708	.88007	1.13627	.91153	1.09706	.94400	1.05932	.97756	1.02295	39
22	.85006	1.17638	.88059	1.13561	.91206	1.09642	.94455	1.05870	.97813	1.02236	38
23	.85057	1.17569	.88110	1.13494	.91259	1.09578	.94510	1.05809	.97870	1.02176	37
24	.85107	1.17500	.88162	1.13428	.91313	1.09514	.94565	1.05747	.97927	1.02117	36
25	.85157	1.17430	.88214	1.13361	.91366	1.09450	.94620	1.05685	.97984	1.02057	35
26	.85207	1.17361	.88265	1.13295	.91419	1.09386	.94676	1.05624	.98041	1.01998	34
27	.85257	1.17292	.88317	1.13228	.91473	1.09322	.94731	1.05562	.98098	1.01939	33
28	.85308	1.17223	.88369	1.13162	.91526	1.09258	.94786	1.05501	.98155	1.01879	32
29	.85358	1.17154	.88421	1.13096	.91580	1.09195	.94841	1.05439	.98213	1.01820	31
30	.85408	1.17085	.88473	1.13029	.91633	1.09131	.94896	1.05378	.98270	1.01761	30
31	.85458	1.17016	.88524	1.12963	.91687	1.09067	.94952	1.05317	.98327	1.01702	29
32	.85509	1.16947	.88576	1.12897	.91740	1.09003	.95007	1.05255	.98384	1.01642	28
33	.85559	1.16878	.88628	1.12831	.91794	1.08940	.95062	1.05194	.98441	1.01583	27
34	.85609	1.16809	.88680	1.12765	.91847	1.08876	.95118	1.05133	.98499	1.01524	26
35	.85660	1.16741	.88732	1.12699	.91901	1.08813	.95173	1.05072	.98556	1.01465	25
36	.85710	1.16672	.88784	1.12633	.91955	1.08749	.95229	1.05010	.98613	1.01406	24
37	.85761	1.16603	.88836	1.12567	.92008	1.08686	.95284	1.04949	.98671	1.01347	23
38	.85811	1.16535	.88888	1.12501	.92062	1.08622	.95340	1.04888	.98728	1.01288	22
39	.85862	1.16466	.88940	1.12435	.92116	1.08559	.95395	1.04827	.98786	1.01229	21
40	.85912	1.16398	.88992	1.12369	.92170	1.08496	.95451	1.04766	.98843	1.01170	20
41	.85963	1.16329	.89045	1.12303	.92224	1.08432	.95506	1.04705	.98901	1.01112	19
42	.86014	1.16261	.89097	1.12238	.92277	1.08369	.95562	1.04644	.98958	1.01053	18
43	.86064	1.16192	.89149	1.12172	.92331	1.08306	.95618	1.04583	.99016	1.00994	17
44	.86115	1.16124	.89201	1.12106	.92385	1.08243	.95673	1.04522	.99073	1.00935	16
45	.86166	1.16056	.89253	1.12041	.92439	1.08179	.95729	1.04461	.99131	1.00876	15
46	.86216	1.15987	.89306	1.11975	.92493	1.08116	.95785	1.04401	.99189	1.00818	14
47	.86267	1.15919	.89358	1.11909	.92547	1.08053	.95841	1.04340	.99247	1.00759	13
48	.86318	1.15851	.89410	1.11844	.92601	1.07990	.95897	1.04279	.99304	1.00701	12
49	.86368	1.15783	.89463	1.11778	.92655	1.07927	.95952	1.04218	.99362	1.00642	11
50	.86419	1.15715	.89515	1.11713	.92709	1.07864	.96008	1.04158	.99420	1.00583	10
51	.86470	1.15647	.89567	1.11648	.92763	1.07801	.96064	1.04097	.99478	1.00525	9
52	.86521	1.15579	.89620	1.11582	.92817	1.07738	.96120	1.04036	.99536	1.00467	8
53	.86572	1.15511	.89672	1.11517	.92872	1.07676	.96176	1.03976	.99594	1.00408	7
54	.86623	1.15443	.89725	1.11452	.92926	1.07613	.96232	1.03915	.99652	1.00350	6
55	.86674	1.15375	.89777	1.11387	.92980	1.07550	.96288	1.03855	.99710	1.00291	5
56	.86725	1.15308	.89830	1.11321	.93034	1.07487	.96344	1.03794	.99768	1.00233	4
57	.86776	1.15240	.89883	1.11256	.93088	1.07425	.96400	1.03734	.99826	1.00175	3
58	.86827	1.15172	.89935	1.11191	.93143	1.07362	.96457	1.03674	.99884	1.00116	2
59	.86878	1.15104	.89988	1.11126	.93197	1.07299	.96513	1.03613	.99942	1.00058	1
60	.86929	1.15037	.90040	1.11061	.93252	1.07237	.96569	1.03553	1.00000	1.00000	0
′	49° Cotang	49° Tang	48° Cotang	48° Tang	47° Cotang	47° Tang	46° Cotang	46° Tang	45° Cotang	45° Tang	′

INDEX MOVEMENTS OF SPIRAL HEAD
FOR
LONGITUDINAL GRADUATING ON A MILLING MACHINE

Movement of Table	Holes	Circle	Movement of Table	Holes	Circle	Movement of Table	Holes	Circle	Movement of Table	Holes	Circle
.0001275	1	49	.0006377	5	49	.0011479	9	49	.0016447	5	19
.0001330	1	47	.0006410	4	39	.0011574	5	27	.0016581	13	49
.0001454	1	43	.0006465	3	29	.0011628	8	43	.0016666	4	15
.0001524	1	41	.0006579	2	19	.0011718	3	16	.0016768	11	41
.0001603	1	39	.0006649	5	47	.0011824	7	37	.0016892	10	37
.0001689	1	37	.0006757	4	37	.0011905	4	21	.0017045	9	33
.0001894	1	33	.0006944	3	27	.0011968	9	47	.0017241	8	29
.0002016	1	31	.0006944	2	18	.0012096	6	31	.0017288	13	47
.0002155	1	29	.0007268	5	43	.0012195	8	41	.0017361	5	18
.0002315	1	27	.0007353	2	17	.0012500	4	20	.0017442	12	43
.0002551	2	49	.0007576	4	33	.0012500	3	15	.0017628	11	39
.0002660	2	47	.0007622	5	41	.0012755	10	49	.0017857	6	21
.0002717	1	23	.0007653	6	49	.0012820	8	39	.0017857	14	49
.0002907	2	43	.0007813	2	16	.0012930	6	29	.0018144	9	31
.0002976	1	21	.0007979	6	47	.0013081	9	43	.0018292	12	41
.0003049	2	41	.0008012	5	39	.0013158	4	19	.0018382	5	17
.0003125	1	20	.0008064	4	31	.0013257	7	33	.0018518	8	27
.0003205	2	39	.0008152	3	23	.0013298	10	47	.0018581	11	37
.0003289	1	19	.0008333	2	15	.0013513	8	37	.0018617	14	47
.0003378	2	37	.0008446	5	37	.0013587	5	23	.001875	6	20
.0003472	1	18	.0008621	4	29	.0013722	9	41	.0018896	13	43
.0003676	1	17	.0008721	6	43	.0013888	6	27	.0018939	10	33
.0003788	2	33	.0008929	7	49	.0013888	4	18	.0019021	7	23
.0003826	3	49	.0008929	3	21	.0014031	11	49	.0019132	15	49
.0003906	1	16	.0009146	6	41	.0014113	7	31	.0019231	12	39
.0003989	3	47	.0009259	4	27	.0014422	9	39	.0019396	9	29
.0004032	2	31	.0009308	7	47	.0014535	10	43	.0019532	5	16
.0004167	1	15	.0009375	3	20	.0014628	11	47	.0019737	6	19
.0004310	2	29	.0009469	5	33	.0014706	4	17	.0019818	13	41
.0004361	3	43	.0009616	6	39	.0014881	5	21	.0019947	15	47
.0004573	3	41	.0009869	3	19	.0015086	7	29	.0020161	10	31
.0004630	2	27	.0010081	5	31	.0015152	8	33	.0020271	12	37
.0004808	3	39	.0010136	6	37	.0015202	9	37	.002035	14	43
.0005068	3	37	.0010174	7	43	.0015244	10	41	.0020485	16	49
.0005102	4	49	.0010204	8	49	.0015306	12	49	.0020833	13	39
.0005319	4	47	.0010417	3	18	.0015625	5	20	.0020833	5	15
.0005435	2	23	.0010638	8	47	.0015625	4	16	.0020833	11	33
.0005682	3	33	.0010671	7	41	.0015957	12	47	.0020833	9	27
.0005814	4	43	.0010776	5	29	.0015989	11	43	.0020833	7	21
.0005952	2	21	.0010869	4	23	.0016026	10	39	.0020833	6	18
.0006048	3	31	.0011029	3	17	.0016128	8	31	.0021277	16	47
.0006098	4	41	.0011218	7	39	.0016204	7	27	.0021342	14	41
.0006250	2	20	.0011363	6	33	.0016303	6	23	.0021552	10	29

INDEX MOVEMENTS OF SPIRAL HEAD
FOR
LONGITUDINAL GRADUATING ON A MILLING MACHINE

Movement of Table	Holes	Circle	Movement of Table	Holes	Circle	Movement of Table	Holes	Circle	Movement of Table	Holes	Circle
.0021682	17	49	.0026785	9	21	.0032014	21	41	.003699	29	49
.0021738	8	23	.0026785	21	49	.003205	20	39	.0037038	16	27
.0021802	15	43	.0027028	16	37	.0032095	19	37	.0037163	22	37
.0021875	7	20	.0027174	10	23	.0032197	17	33	.0037234	28	47
.002196	13	37	.0027243	17	39	.0032257	16	31	.003750	12	20
.0022059	6	17	.0027344	7	16	.0032327	15	29	.003750	9	15
.0022176	11	31	.002744	18	41	.0032408	14	27	.0037793	26	43
.0022436	14	39	.0027618	19	43	.0032607	12	23	.0037878	20	33
.0022607	17	47	.0027777	8	18	.0032738	11	21	.0038043	14	23
.0022728	12	33	.0027777	12	27	.0032895	10	19	.0038112	25	41
.0022866	15	41	.0027925	21	47	.0033088	9	17	.0038195	11	18
.0022959	18	49	.0028017	13	29	.0033164	26	49	.0038265	30	49
.0023027	7	19	.002806	22	49	.0033245	25	47	.0038305	19	31
.0023148	10	27	.0028125	9	20	.0033333	8	15	.003846	24	39
.0023257	16	43	.0028225	14	31	.0033431	23	43	.0038564	29	47
.0023438	6	16	.0028409	15	33	.0033538	22	41	.0038692	13	21
.0023649	14	37	.0028717	17	37	.0033654	21	39	.0038794	18	29
.0023706	11	29	.0028846	18	39	.0033784	20	37	.0038853	23	37
.0023809	8	21	.0028963	19	41	.0034091	18	33	.0039063	10	16
.0023937	18	47	.002907	20	43	.0034273	17	31	.0039246	27	43
.0024038	15	39	.0029167	7	15	.0034375	11	20	.0039352	17	27
.0024192	12	31	.0029256	22	47	.0034439	27	49	.0039475	12	19
.0024235	19	49	.0029337	23	49	.0034482	16	29	.003954	31	49
.0024306	7	18	.0029412	8	17	.0034574	26	47	.0039636	26	41
.002439	16	41	.0029605	9	19	.0034722	10	18	.0039773	21	33
.0024455	9	23	.0029762	10	21	.0034722	15	27	.0039894	30	47
.0024622	13	33	.002989	11	23	.0034885	24	43	.0040064	25	39
.002471	17	43	.0030094	13	27	.0035063	23	41	.0040322	20	31
.00250	8	20	.0030172	14	29	.0035156	9	16	.0040443	11	17
.00250	6	15	.0030241	15	31	.0035255	22	39	.0040541	24	37
.0025266	19	47	.0030303	16	33	.0035325	13	23	.0040625	13	20
.0025339	15	37	.0030406	18	37	.0035474	21	37	.00407	28	43
.0025463	11	27	.0030448	19	39	.0035714	12	21	.0040759	15	23
.002551	20	49	.0030488	20	41	.0035714	28	49	.0040817	32	49
.002564	16	39	.0030524	21	43	.0035904	27	47	.0040948	19	29
.0025736	7	17	.0030586	23	47	.0035984	19	33	.004116	27	41
.0025862	12	29	.0030611	24	49	.0036186	11	19	.0041223	31	47
.0025915	17	41	.003125	9	18	.0036289	18	31	.0041666	22	33
.0026164	18	43	.003125	10	20	.0036339	25	43	.0041666	14	21
.0026209	13	31	.003125	8	16	.0036585	24	41	.0041666	18	27
.0026316	8	19	.0031889	25	49	.0036637	17	29	.0041666	12	18
.0026515	14	33	.0031915	24	47	.0036765	10	17	.0041666	10	15
.0026596	20	47	.0031978	22	43	.0036858	23	39	.0041666	26	39

INDEX MOVEMENTS OF SPIRAL HEAD FOR LONGITUDINAL GRADUATING ON A MILLING MACHINE

Movement of Table	Holes	Circle	Movement of Table	Holes	Circle	Movement of Table	Holes	Circle	Movement of Table	Holes	Circle
.0042091	33	49	.0047256	31	41	.0052327	36	43	.0057433	34	37
.0042152	29	43	.0047299	28	37	.0052365	31	37	.0057692	36	39
.0042232	25	37	.0047349	25	33	.0052419	26	31	.0057874	25	27
.0042338	21	31	.0047414	22	29	.0052635	16	19	.0057927	38	41
.0042553	32	47	.004762	16	21	.0052884	33	39	.0058142	40	43
.0042685	28	41	.0047796	13	17	.005303	28	33	.0058187	27	29
.0042765	13	19	.0047873	36	47	.0053125	17	20	.0058336	14	15
.0042971	11	16	.0047968	33	43	.0053194	40	47	.0058466	29	31
.0043104	20	29	.0048074	30	39	.0053242	23	27	.0058512	44	47
.0043268	27	39	.0048384	24	31	.0053364	35	41	.0058599	15	16
.0043368	34	49	.004847	38	49	.0053572	42	49	.0058674	46	49
.0043477	16	23	.0048613	14	18	.0053572	18	21	.005871	31	33
.0043562	23	33	.0048613	21	27	.0053781	37	43	.0058825	16	17
.0043605	30	43	.0048782	32	41	.005388	25	29	.0059027	17	18
.004375	14	20	.0048912	18	23	.0054057	32	37	.0059122	35	37
.0043883	33	47	.0048989	29	37	.005417	13	15	.0059215	18	19
.0043922	26	37	.0049202	37	47	.0054348	20	23	.0059294	37	39
.004398	19	27	.0049244	26	33	.0054434	27	31	.0059375	19	20
.0044119	12	17	.0049345	15	19	.0054486	34	39	.0059455	39	41
.004421	29	41	.004942	34	43	.0054522	41	47	.0059524	20	21
.0044354	22	31	.0049569	23	29	.005469	14	16	.0059598	41	43
.0044643	15	21	.0049677	31	39	.0054848	43	49	.0059782	22	23
.0044643	35	49	.0049745	39	49	.0054878	36	41	.0059841	45	47
.0044871	28	39	.005	16	20	.0054924	29	33	.0059951	47	49
.004506	31	43	.005	12	15	.0055148	15	17	.0060188	26	27
.004514	13	18	.0050308	33	41	.0055238	38	43	.0060346	28	29
.0045213	34	47	.0050402	25	31	.0055555	24	27	.006048	30	31
.0045259	21	29	.0050532	38	47	.0055555	16	18	.0060607	32	33
.0045452	24	33	.0050596	17	21	.0055746	33	37	.0060812	36	37
.004561	27	37	.0050676	30	37	.0055852	42	47	.0060898	38	39
.0045732	30	41	.0050785	13	16	.0055925	17	19	.006098	40	41
.0045835	11	15	.0050876	35	43	.0056035	26	29	.0061052	42	43
.004592	36	49	.0050928	22	27	.0056088	35	39	.0061171	46	47
.0046055	14	19	.0051022	40	49	.0056123	44	49	.0061224	48	49
.0046194	17	23	.0051136	27	33	.005625	18	20	.00625		1
.0046296	20	27	.0051281	32	39	.0056403	37	41			
.0046371	23	31	.0051474	14	17	.005645	28	31			
.0046473	29	39	.0051627	19	23	.0056546	19	21			
.0046512	32	43	.0051721	24	29	.005669	39	43			
.0046543	35	47	.005183	34	41	.0056816	30	33			
.0046875	15	20	.0051861	39	47	.0057065	21	23			
.0046875	12	16	.0052083	15	18	.005718	43	47			
.0047195	37	49	.0052296	41	49	.00574	45	49			

TABLE OF TOOTH PARTS

CIRCULAR PITCH IN FIRST COLUMN

Circular Pitch.	Threads or Teeth per inch Linear.	Diametral Pitch.	Thickness of Tooth on Pitch Line.	Addendum and Module.	Working Depth of Tooth.	Depth of Space below Pitch Line.	Whole Depth of Tooth.	Width of Thread-Tool at End.	Width of Thread at Top.
P'	$\frac{1''}{P'}$	P	t	s	D''	$s+f$	$D''+f$	$P' \times .3095$	$P' \times .3354$
2	$\frac{1}{2}$	1.5708	1.0000	.6366	1.2732	.7366	1.3732	.6190	.6707
$1\frac{7}{8}$	$\frac{8}{15}$	1.6755	.9375	.5968	1.1937	.6906	1.2874	.5803	.6288
$1\frac{3}{4}$	$\frac{4}{7}$	1.7952	.8750	.5570	1.1141	.6445	1.2016	.5416	.5869
$1\frac{5}{8}$	$\frac{8}{13}$	1.9333	.8125	.5173	1.0345	.5985	1.1158	.5029	.5450
$1\frac{1}{2}$	$\frac{2}{3}$	2.0944	.7500	.4775	.9549	.5525	1.0299	.4642	.5030
$1\frac{7}{16}$	$\frac{16}{23}$	2.1855	.7187	.4576	.9151	.5294	.9870	.4449	.4821
$1\frac{3}{8}$	$\frac{8}{11}$	2.2848	.6875	.4377	.8754	.5064	.9441	.4256	.4611
$1\frac{1}{3}$	$\frac{3}{4}$	2.3562	.6666	.4244	.8488	.4910	.9154	.4127	.4471
$1\frac{5}{16}$	$\frac{16}{21}$	2.3936	.6562	.4178	.8356	.4834	.9012	.4062	.4402
$1\frac{1}{4}$	$\frac{4}{5}$	2.5133	.6250	.3979	.7958	.4604	.8583	.3869	.4192
$1\frac{3}{16}$	$\frac{16}{19}$	2.6456	.5937	.3780	.7560	.4374	.8154	.3675	.3982
$1\frac{1}{8}$	$\frac{8}{9}$	2.7925	.5625	.3581	.7162	.4143	.7724	.3482	.3773
$1\frac{1}{16}$	$\frac{16}{17}$	2.9568	.5312	.3382	.6764	.3913	.7295	.3288	.3563
1	1	3.1416	.5000	.3183	.6366	.3683	.6866	.3095	.3354
$\frac{15}{16}$	$1\frac{1}{15}$	3.3510	.4687	.2984	.5968	.3453	.6437	.2902	.3144
$\frac{7}{8}$	$1\frac{1}{7}$	3.5904	.4375	.2785	.5570	.3223	.6007	.2708	.2934
$\frac{13}{16}$	$1\frac{3}{13}$	3.8666	.4062	.2586	.5173	.2993	.5579	.2515	.2725
$\frac{4}{5}$	$1\frac{1}{4}$	3.9270	.4000	.2546	.5092	.2946	.5492	.2476	.2683
$\frac{3}{4}$	$1\frac{1}{3}$	4.1888	.3750	.2387	.4775	.2762	.5150	.2321	.2515
$\frac{11}{16}$	$1\frac{5}{11}$	4.5696	.3437	.2189	.4377	.2532	.4720	.2128	.2306
$\frac{2}{3}$	$1\frac{1}{2}$	4.7124	.3333	.2122	.4244	.2455	.4577	.2063	.2236
$\frac{5}{8}$	$1\frac{3}{5}$	5.0265	.3125	.1989	.3979	.2301	.4291	.1934	.2096
$\frac{3}{5}$	$1\frac{2}{3}$	5.2360	.3000	.1910	.3820	.2210	.4120	.1857	.2012
$\frac{4}{7}$	$1\frac{3}{4}$	5.4978	.2857	.1819	.3638	.2105	.3923	.1769	.1916
$\frac{9}{16}$	$1\frac{7}{9}$	5.5851	.2812	.1790	.3581	.2071	.3862	.1741	.1886

TABLE OF TOOTH PARTS—CONTINUED

CIRCULAR PITCH IN FIRST COLUMN

Circular Pitch.	Threads or Teeth per inch Linear.	Diametral Pitch.	Thickness of Tooth on Pitch Line.	Addendum and Module.	Working Depth of Tooth.	Depth of Space below Pitch Line.	Whole Depth of Tooth.	Width of Thread-Tool at End.	Width of Thread at Top.
P'	$\frac{1''}{P'}$	P	t	s	D''	$s+f$	$D''+f.$	$P' \times .3095$	$P' \times .3354$
$\frac{1}{2}$	2	6.2832	.2500	.1592	.3183	.1842	.3433	.1547	.1677
$\frac{4}{9}$	$2\frac{1}{4}$	7.0685	.2222	.1415	.2830	.1637	.3052	.1376	.1490
$\frac{7}{16}$	$2\frac{2}{7}$	7.1808	.2187	.1393	.2785	.1611	.3003	.1354	.1467
$\frac{3}{7}$	$2\frac{1}{3}$	7.3304	.2143	.1364	.2728	.1578	.2942	.1326	.1437
$\frac{2}{5}$	$2\frac{1}{2}$	7.8540	.2000	.1273	.2546	.1473	.2746	.1238	.1341
$\frac{3}{8}$	$2\frac{2}{3}$	8.3776	.1875	.1194	.2387	.1381	.2575	.1161	.1258
$\frac{4}{11}$	$2\frac{3}{4}$	8.6394	.1818	.1158	.2316	.1340	.2498	.1125	.1219
$\frac{1}{3}$	3	9.4248	.1666	.1061	.2122	.1228	.2289	.1032	.1118
$\frac{5}{16}$	$3\frac{1}{5}$	10.0531	.1562	.0995	.1989	.1151	.2146	.0967	.1048
$\frac{3}{10}$	$3\frac{1}{3}$	10.4719	.1500	.0955	.1910	.1105	.2060	.0928	.1006
$\frac{2}{7}$	$3\frac{1}{2}$	10.9956	.1429	.0909	.1819	.1052	.1962	.0884	.0958
$\frac{1}{4}$	4	12.5664	.1250	.0796	.1591	.0921	.1716	.0774	.0838
$\frac{2}{9}$	$4\frac{1}{2}$	14.1372	.1111	.0707	.1415	.0818	.1526	.0688	.0745
$\frac{1}{5}$	5	15.7080	.1000	.0637	.1273	.0737	.1373	.0619	.0671
$\frac{3}{16}$	$5\frac{1}{3}$	16.7552	.0937	.0597	.1194	.0690	.1287	.0580	.0629
$\frac{2}{11}$	$5\frac{1}{2}$	17.2788	.0909	.0579	.1158	.0670	.1249	.0563	.0610
$\frac{1}{6}$	6	18.8496	.0833	.0531	.1061	.0614	.1144	.0516	.0559
$\frac{2}{13}$	$6\frac{1}{2}$	20.4203	.0769	.0489	.0978	.0566	.1055	.0476	.0516
$\frac{1}{7}$	7	21.9911	.0714	.0455	.0910	.0526	.0981	.0442	.0479
$\frac{2}{15}$	$7\frac{1}{2}$	23.5619	.0666	.0425	.0850	.0492	.0917	.0413	.0447
$\frac{1}{8}$	8	25.1327	.0625	.0398	.0796	.0460	.0858	.0387	.0419
$\frac{1}{9}$	9	28.2743	.0555	.0354	.0707	.0409	.0763	.0344	.0373
$\frac{1}{10}$	10	31.4159	.0500	.0318	.0637	.0368	.0687	.0309	.0335
$\frac{1}{16}$	16	50.2655	.0312	.0199	.0398	.0230	.0429	.0193	.0210
$\frac{1}{20}$	20	62.8318	.0250	.0159	.0318	.0184	.0343	.0155	.0168

TABLE OF TOOTH PARTS

DIAMETRAL PITCH IN FIRST COLUMN

Diametral Pitch.	Circular Pitch.	Thickness of Tooth on Pitch Line.	Addendum and Module.	Working Depth of Tooth.	Depth of Space below Pitch Line.	Whole Depth of Tooth.
P	P′	*t*	*s*	D″	*s* + *f*.	D″ + *f*.
½	6.2832	3.1416	2.0000	4.0000	2.3142	4.3142
¾	4.1888	2.0944	1.3333	2.6666	1.5428	2.8761
1	3.1416	1.5708	1.0000	2.0000	1.1571	2.1571
1¼	2.5133	1.2566	.8000	1.6000	.9257	1.7257
1½	2.0944	1.0472	.6666	1.3333	.7714	1.4381
1¾	1.7952	.8976	.5714	1.1429	.6612	1.2326
2	1.5708	.7854	.5000	1.0000	.5785	1.0785
2¼	1.3963	.6981	.4444	.8888	.5143	.9587
2½	1.2566	.6283	.4000	.8000	.4628	.8628
2¾	1.1424	.5712	.3636	.7273	.4208	.7844
3	1.0472	.5236	.3333	.6666	.3857	.7190
3½	.8976	.4488	.2857	.5714	.3306	.6163
4	.7854	.3927	.2500	.5000	.2893	.5393
5	.6283	.3142	.2000	.4000	.2314	.4314
6	.5236	.2618	.1666	.3333	.1928	.3595
7	.4488	.2244	.1429	.2857	.1653	.3081
8	.3927	.1963	.1250	.2500	.1446	.2696
9	.3491	.1745	.1111	.2222	.1286	.2397
10	.3142	.1571	.1000	.2000	.1157	.2157
11	.2856	.1428	.0909	.1818	.1052	.1961
12	.2618	.1309	.0833	.1666	.0964	.1798
13	.2417	.1208	.0769	.1538	.0890	.1659
14	.2244	.1122	.0714	.1429	.0826	.1541

TABLE OF TOOTH PARTS—CONTINUED

DIAMETRAL PITCH IN FIRST COLUMN

Diametral Pitch.	Circular Pitch.	Thickness of Tooth on Pitch Line.	$\frac{1}{P}$ or the Addendum or Module.	Working Depth of Tooth.	Depth of Space below Pitch Line.	Whole Depth of Tooth.
P.	P′.	t.	s.	D″.	$s+f$.	D″+f.
15	.2094	.1047	.0666	.1333	.0771	.1438
16	.1963	.0982	.0625	.1250	.0723	.1348
17	.1848	.0924	.0588	.1176	.0681	.1269
18	.1745	.0873	.0555	.1111	.0643	.1198
19	.1653	.0827	.0526	.1053	.0609	.1135
20	.1571	.0785	.0500	1000	.0579	.1079
22	.1428	.0714	.0455	.0909	.0526	.0980
24	.1309	.0654	.0417	.0833	.0482	.0898
26	.1208	.0604	.0385	.0769	.0445	.0829
28	.1122	.0561	.0357	.0714	.0413	.0770
30	.1047	.0524	.0333	.0666	.0386	.0719
32	.0982	.0491	.0312	.0625	.0362	.0674
34	.0924	.0462	.0294	.0588	.0340	.0634
36	.0873	.0436	.0278	.0555	.0321	.0599
38	.0827	.0413	.0263	.0526	.0304	.0568
40	.0785	.0393	.0250	.0500	.0289	.0539
42	.0748	.0374	.0238	.0476	.0275	.0514
44	.0714	.0357	.0227	.0455	.0263	.0490
46	.0683	.0341	.0217	.0435	.0252	.0469
48	.0654	.0327	.0208	.0417	.0241	.0449
50	.0628	.0314	.0200	.0400	.0231	.0431
56	.0561	.0280	.0178	.0357	.0207	.0385
60	.0524	.0262	.0166	.0333	.0193	.0360

TABLE GIVING CHORDAL THICKNESS OF GEAR TEETH (t'') AND DISTANCE FROM CHORD TO TOP OF TOOTH (s'')

NUMBER OF TEETH	t''	s''	NUMBER OF TEETH	t''	s''	NUMBER OF TEETH	t''	s''
						94	1.5707	1.0066
6	1.5529	1.1022	50	1.5705	1.0123	95	1.5707	1.0065
7	1.5568	1.0873	51	1.5706	1.0121	96	1.5707	1.0064
8	1.5607	1.0769	52	1.5706	1.0119	97	1.5707	1.0064
9	1.5628	1.0684	53	1.5706	1.0117	98	1.5707	1.0063
10	1.5643	1.0616	54	1.5706	1.0114	99	1.5707	1.0062
11	1.5654	1.0559	55	1.5706	1.0112	100	1.5707	1.0061
12	1.5663	1.0514	56	1.5706	1.0110	101	1.5707	1.0061
13	1.5670	1.0474	57	1.5706	1.0108	102	1.5707	1.0060
14	1.5675	1.0440	58	1.5706	1.0106	103	1.5707	1.0060
15	1.5679	1.0411	59	1.5706	1.0105	104	1.5707	1.0059
16	1.5683	1.0385	60	1.5706	1.0102	105	1.5707	1.0059
17	1.5686	1.0362	61	1.5706	1.0101	106	1.5707	1.0058
18	1.5688	1.0342	62	1.5706	1.0100	107	1.5707	1.0058
19	1.5690	1.0324	63	1.5706	1.0098	108	1.5707	1.0057
20	1.5692	1.0308	64	1.5706	1.0097	109	1.5707	1.0057
21	1.5694	1.0294	65	1.5706	1.0095	110	1.5707	1.0056
22	1.5695	1.0281	66	1.5706	1.0094	111	1.5707	1.0056
23	1.5696	1.0268	67	1.5706	1.0092	112	1.5707	1.0055
24	1.5697	1.0257	68	1.5706	1.0091	113	1.5707	1.0055
25	1.5698	1.0247	69	1.5707	1.0090	114	1.5707	1.0054
26	1.5698	1.0237	70	1.5707	1.0088	115	1.5707	1.0054
27	1.5699	1.0228	71	1.5707	1.0087	116	1.5707	1.0053
28	1.5700	1.0220	72	1.5707	1.0086	117	1.5707	1.0053
29	1.5700	1.0213	73	1.5707	1.0085	118	1.5707	1.0053
30	1.5701	1.0208	74	1.5707	1.0084	119	1.5707	1.0052
31	1.5701	1.0199	75	1.5707	1.0083	120	1.5707	1.0052
32	1.5702	1.0193	76	1.5707	1.0081	121	1.5707	1.0051
33	1.5702	1.0187	77	1.5707	1.0080	122	1.5707	1.0051
34	1.5702	1.0181	78	1.5707	1.0079	123	1.5707	1.0050
35	1.5702	1.0176	79	1.5707	1.0078	124	1.5707	1.0050
36	1.5703	1.0171	80	1.5707	1.0077	125	1.5707	1.0049
37	1.5703	1.0167	81	1.5707	1.0076	126	1.5707	1.0049
38	1.5703	1.0162	82	1.5707	1.0075	127	1.5707	1.0049
39	1.5704	1.0158	83	1.5707	1.0074	128	1.5707	1.0048
40	1.5704	1.0154	84	1.5707	1.0074	129	1.5707	1.0048
41	1.5704	1.0150	85	1.5707	1.0073	130	1.5707	1.0047
42	1.5704	1.0147	86	1.5707	1.0072	131	1.5708	1.0047
43	1.5705	1.0143	87	1.5707	1.0071	132	1.5708	1.0047
44	1.5705	1.0140	88	1.5707	1.0070	133	1.5708	1.0047
45	1.5705	1.0137	89	1.5707	1.0069	134	1.5708	1.0046
46	1.5705	1.0134	90	1.5707	1.0068	135	1.5708	1.0046
47	1.5705	1.0131	91	1.5707	1.0068			
48	1.5705	1.0129	92	1.5707	1.0067			
49	1.5705	1.0126	93	1.5707	1.0067			

TABLE FOR OBTAINING SET-OVER FOR CUTTING BEVEL GEARS

RATIO OF APEX DISTANCE TO WIDTH OF FACE $= \frac{\text{APEX}}{\text{FACE}}$

No. of Cutter	3/1	3¼/1	3½/1	3¾/1	4/1	4¼/1	4½/1	4¾/1	5/1	5½/1	6/1	7/1	8/1
1	.254	.254	.255	.256	.257	.257	.257	.258	.258	.259	.260	.262	.264
2	.266	.268	.271	.272	.273	.274	.274	.275	.277	.279	.280	.283	.284
3	.266	.268	.271	.273	.275	.278	.280	.282	.283	.286	.287	.290	.292
4	.275	.280	.285	.287	.291	.293	.296	.298	.298	.302	.305	.308	.311
5	.280	.285	.290	.293	.295	.296	.298	.300	.302	.307	.309	.313	.315
6	.311	.318	.323	.328	.330	.334	.337	.340	.343	.348	.352	.356	.362
7	.289	.298	.308	.316	.324	.329	.334	.338	.343	.350	.360	.370	.376
8	.275	.286	.296	.309	.319	.331	.338	.344	.352	.361	.368	.380	.386

TABLE OF CUTTERS, PITCHES, GEARS AND ANGLES FOR TWIST DRILLS

Diameter of Drill	Thickness of Cutter	Pitch in Inches	Gear on Worm	First Gear on Stud	Second Gear on Stud	Gear on Screw	Angle of Spiral
$\frac{1}{16}$	.06	.67	24	86	24	100	16° 20′
$\frac{1}{8}$	.08	1.12	24	86	40	100	19° 20′
$\frac{3}{16}$	.11	1.67	24	64	32	72	19° 25′
$\frac{1}{4}$	.15	1.94	32	64	28	72	21°
$\frac{5}{16}$	.19	2.92	24	64	56	72	20°
$\frac{3}{8}$	.23	3.24	40	48	28	72	21°
$\frac{7}{16}$	.27	3.89	56	48	24	72	20° 10′
$\frac{1}{2}$	.31	4.17	40	72	48	64	20° 30′
$\frac{9}{16}$	.35	4.86	40	64	56	72	20°
$\frac{5}{8}$	.39	5.33	48	40	32	72	20° 12′
$\frac{11}{16}$	.44	6.12	56	40	28	64	19° 30′
$\frac{3}{4}$	.50	6.48	56	48	40	72	20°
$\frac{13}{16}$	.56	7.29	56	48	40	64	19° 20′
$\frac{7}{8}$	.62	7.62	64	48	32	56	19° 50′
$\frac{15}{16}$	.70	8.33	48	32	40	72	19° 30′
1	.77	8.95	86	48	28	56	19° 20′
$1\frac{1}{8}$	.85	9.33	56	40	48	72	20° 40′

TABLE OF CUTTING SPEEDS

FT. PER MINUTE	15	17.5	20	22.5	25	27.5	30	35	40	45	50	55
DIAM.	REVOLUTIONS PER MINUTE											
1/16	917	1070	1222	1375	1528	1681	1833	2139	2445	2750	3056	3361
1/8	458	535	611	688	764	840	917	1070	1222	1375	1528	1681
3/16	306	357	407	458	509	560	611	713	815	917	1019	1120
1/4	229	267	306	344	382	420	458	535	611	688	764	840
5/16	183	214	244	275	306	336	367	428	489	550	611	672
3/8	153	178	204	229	255	280	306	357	407	458	509	560
7/16	131	153	175	196	218	240	262	306	349	393	437	480
1/2	115	134	153	172	191	210	229	267	306	344	382	420
5/8	91.7	107	122	138	153	168	183	214	244	275	306	336
3/4	76.4	89.1	102	115	127	140	153	178	204	229	255	280
7/8	65.5	76.4	87.3	98.2	109	120	131	153	175	196	218	240
1	57.3	66.8	76.4	85.9	95.5	105	115	134	153	172	191	210
1 1/8	50.9	59.4	67.9	76.4	84.9	93.4	102	119	136	153	170	187
1 1/4	45.8	53.5	61.1	68.8	76.4	84.0	91.7	107	122	138	153	168
1 3/8	41.7	48.6	55.6	62.5	69.5	76.4	83.3	97.2	111	125	139	153
1 1/2	38.2	44.6	50.9	57.3	63.7	70.0	76.4	89.1	102	115	127	140
1 5/8	35.3	41.1	47.0	52.9	58.8	64.6	70.5	82.3	94.0	106	118	129
1 3/4	32.7	38.2	43.7	49.1	54.6	60.0	65.5	76.4	87.3	98.2	109	120
1 7/8	30.6	35.7	40.7	45.8	50.9	56.0	61.1	71.3	81.5	91.7	102	112
2	28.7	33.4	38.2	43.0	47.7	52.5	57.3	66.8	76.4	85.9	95.5	105
2 1/4	25.5	29.7	34.0	38.2	42.4	46.7	50.9	59.4	67.9	76.4	84.9	93.4
2 1/2	22.9	26.7	30.6	34.4	38.2	42.0	45.8	53.5	61.1	68.8	76.4	84.0
2 3/4	20.8	24.3	27.8	31.3	34.7	38.2	41.7	48.6	55.6	62.5	69.5	76.4
3	19.1	22.3	25.5	28.6	31.8	35.0	38.2	44.6	50.9	57.3	63.7	70.0
3 1/4	17.6	20.6	23.5	26.4	29.4	32.3	35.3	41.1	47.0	52.9	58.8	64.6
3 1/2	16.4	19.1	21.8	24.5	27.3	30.0	32.7	38.2	43.7	49.1	54.6	60.0
3 3/4	15.3	17.8	20.4	22.9	25.5	28.0	30.6	35.7	40.7	45.8	50.9	56.0
4	14.3	16.7	19.1	21.5	23.9	26.3	28.7	33.4	38.2	43.0	47.7	52.5
4 1/2	12.7	14.9	17.0	19.1	21.2	23.3	25.5	29.7	34.0	38.2	42.4	46.7
5	11.5	13.4	15.3	17.2	19.1	21.0	22.9	26.7	30.6	34.4	38.2	42.0
5 1/2	10.4	12.2	13.9	15.6	17.4	19.1	20.8	24.3	27.8	31.3	34.7	38.2
6	9.5	11.1	12.7	14.3	15.9	17.5	19.1	22.3	25.5	28.6	31.8	35.0
6 1/2	8.8	10.3	11.8	13.2	14.7	16.2	17.6	20.6	23.5	26.4	29.4	32.3
7	8.2	9.5	10.9	12.3	13.6	15.0	16.4	19.1	21.8	24.5	27.3	30.0
7 1/2	7.6	8.9	10.2	11.5	12.7	14.0	15.3	17.8	20.4	22.9	25.5	28.0
8	7.2	8.4	9.5	10.7	11.9	13.1	14.3	16.7	19.1	21.5	23.9	26.3
8 1/2	6.7	7.9	9.0	10.1	11.2	12.4	13.5	15.7	18.0	20.2	22.5	24.7
9	6.4	7.4	8.5	9.5	10.6	11.7	12.7	14.9	17.0	19.1	21.2	23.3
9 1/2	6.0	7.0	8.0	9.1	10.1	11.1	12.1	14.1	16.1	18.1	20.1	22.1
10	5.7	6.7	7.6	8.6	9.5	10.5	11.5	13.4	15.3	17.2	19.1	21.0
11	5.2	6.1	6.9	7.8	8.7	9.5	10.4	12.2	13.9	15.6	17.4	19.1
12	4.8	5.6	6.4	7.2	8.0	8.8	9.5	11.1	12.7	14.3	15.9	17.5
13	4.4	5.1	5.9	6.6	7.3	8.1	8.8	10.3	11.8	13.2	14.7	16.2
14	4.1	4.8	5.5	6.1	6.8	7.5	8.2	9.5	10.9	12.3	13.6	15.0
15	3.8	4.5	5.1	5.7	6.4	7.0	7.6	8.9	10.2	11.5	12.7	14.0
16	3.6	4.2	4.8	5.4	6.0	6.6	7.2	8.4	9.5	10.7	11.9	13.1
17	3.4	3.9	4.5	5.1	5.6	6.2	6.7	7.9	9.0	10.1	11.2	12.4
18	3.2	3.7	4.2	4.8	5.3	5.8	6.4	7.4	8.5	9.5	10.6	11.7
	15	17.5	20	22.5	25	27.5	30	35	40	45	50	55

TABLE OF CUTTING SPEEDS—CONTINUED

FT. PER MINUTE	60	65	70	75	80	90	100	110	120	130	140	150
DIAM.	REVOLUTIONS PER MINUTE											
1/16	3667	3973	4278	4584	4889							
1/8	1833	1986	2139	2292	2445	2750	3056	3361	3667	3973	4278	4584
3/16	1222	1324	1426	1528	1630	1833	2037	2241	2445	2648	2852	3056
1/4	917	993	1070	1146	1222	1375	1528	1681	1833	1986	2139	2292
5/16	733	794	856	917	978	1100	1222	1345	1467	1589	1711	1833
3/8	611	662	713	764	815	917	1019	1120	1222	1324	1426	1528
7/16	524	568	611	655	698	786	873	960	1048	1135	1222	1310
1/2	458	497	535	573	611	688	764	840	917	993	1070	1146
5/8	367	397	428	458	489	550	611	672	733	794	856	917
3/4	306	331	357	382	407	458	509	560	611	662	713	764
7/8	262	284	306	327	349	393	437	480	524	568	611	655
1	229	248	267	287	306	344	382	420	458	497	535	573
1 1/8	204	221	238	255	272	306	340	373	407	441	475	509
1 1/4	183	199	214	229	244	275	306	336	367	397	428	458
1 3/8	167	181	194	208	222	250	278	306	333	361	389	417
1 1/2	153	166	178	191	204	229	255	280	306	331	357	382
1 5/8	141	153	165	176	188	212	235	259	282	306	329	353
1 3/4	131	142	153	164	175	196	218	240	262	284	306	327
1 7/8	122	132	143	153	163	183	204	224	244	265	285	306
2	115	124	134	143	153	172	191	210	229	248	267	287
2 1/4	102	110	119	127	136	153	170	187	204	221	238	255
2 1/2	91.7	99.3	107	115	122	138	153	168	183	199	214	229
2 3/4	83.3	90.3	97.2	104	111	125	139	153	167	181	194	208
3	76.4	82.8	89.1	95.5	102	115	127	140	153	166	178	191
3 1/4	70.5	76.4	82.3	88.2	94.0	106	118	129	141	153	165	176
3 1/2	65.5	70.9	76.4	81.9	87.3	98.2	109	120	131	142	153	164
3 3/4	61.1	66.2	71.3	76.4	81.5	91.7	102	112	122	132	143	153
4	57.3	62.1	66.8	71.6	76.4	85.9	95.5	105	115	124	134	143
4 1/2	50.9	55.2	59.4	63.6	67.9	76.4	84.9	93.4	102	110	119	127
5	45.8	49.7	53.5	57.3	61.1	68.8	76.4	84.0	91.7	99.3	107	115
5 1/2	41.7	45.1	48.6	52.1	55.6	62.5	69.5	76.4	83.3	90.3	97.2	104
6	38.2	41.4	44.6	47.8	50.9	57.3	63.7	70.0	76.4	82.8	89.1	95.5
6 1/2	35.3	38.2	41.1	44.1	47.0	52.9	58.8	64.6	70.5	76.4	82.3	88.2
7	32.7	35.5	38.2	40.9	43.7	49.1	54.6	60.0	65.5	70.9	76.4	81.9
7 1/2	30.6	33.1	35.7	38.2	40.7	45.8	50.9	56.0	61.1	66.2	71.3	76.4
8	28.7	31.0	33.4	35.8	38.2	43.0	47.7	52.5	57.3	62.1	66.8	71.6
8 1/2	27.0	29.2	31.5	33.7	36.0	40.4	44.9	49.4	53.9	58.4	62.9	67.4
9	25.5	27.6	29.7	31.8	34.0	38.2	42.4	46.7	50.9	55.2	59.4	63.6
9 1/2	24.1	26.1	28.2	30.2	32.2	36.2	40.2	44.2	48.3	52.3	56.3	60.3
10	22.9	24.8	26.7	28.7	30.6	34.4	38.2	42.0	45.8	49.7	53.5	57.3
11	20.8	22.6	24.3	26.0	27.8	31.3	34.7	38.2	41.7	45.1	48.6	52.1
12	19.1	20.7	22.3	23.9	25.5	28.6	31.8	35.0	38.2	41.4	44.6	47.8
13	17.6	19.1	20.6	22.0	23.5	26.4	29.4	32.3	35.3	38.2	41.1	44.1
14	16.4	17.7	19.1	20.5	21.8	24.5	27.3	30.0	32.7	35.5	38.2	40.9
15	15.3	16.6	17.8	19.1	20.4	22.9	25.5	28.0	30.6	33.1	35.7	38.2
16	14.3	15.5	16.7	17.9	19.1	21.5	23.9	26.3	28.7	31.0	33.4	35.8
17	13.5	14.6	15.7	16.9	18.0	20.2	22.5	24.7	27.0	29.2	31.5	33.7
18	12.7	13.8	14.9	15.9	17.0	19.1	21.2	23.3	25.5	27.6	29.7	31.8
	60	65	70	75	80	90	100	110	120	130	140	150

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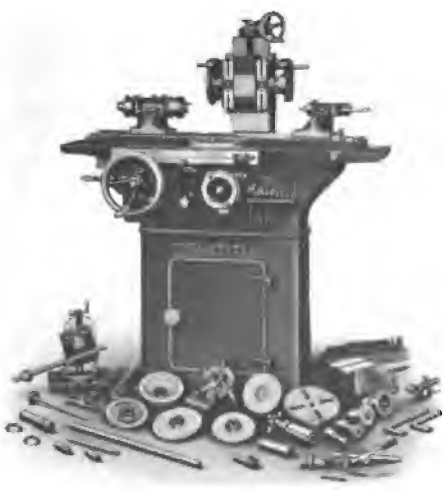

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